FAA-E-2506
November 12, 1971

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

AIRPORT SURVEILLANCE RADAR (ASR) TRANSMITTER RECEIVER (T/R) SUBSYSTEM

1. SCOPE

1.1 Scope.- The equipment specified herein is the radar transmitter/receiver (T/R) subsystem of an Airport Surveillance Radar (ASR) system capable of providing rho-theta information on aircraft targets within a 60 nautical mile radius centered on the radar. The target rho-theta information is normally transmitted via coaxial cable or microwave link to a terminal control facility where it is displayed or utilized in some other manner for control of air traffic. The T/R subsystem consists of dual radar channels, an antenna unit, a control unit, and other required ancillary items. Major units of each radar channel are a transmitter, receiver, reply processor and necessary control circuits. The equipment may be installed in transportable buildings (each channel in a separate but colocated building) or in a single, fixed building. Design features are included to permit installation in either of the above types of facility; to permit interface with radar beacon, microwave link and other associated equipment; and to provide performance, reliability and maintainability characteristics consistent with the stringent requirements of air traffic control.

2. APPLICABLE DOCUMENTS

2.1 FAA Specifications.- The following FAA specifications of the issues specified in the invitation for bids or request for proposals form a part of this specification:

FAA-D-638	Instruction Books, Electronic Equipment

FAA-G-2100/1	Electronic Equipment, General Requirements Part 1, Basic Requirements for All Equipments
FAA-G-2100/3	Part 3, Requirements for Equipments Employing Semiconductor Devices
FAA-G-2100/4	Part 4, Requirements for Equipments Employing Printed Wiring Techniques
FAA-G-2100/5	Part 5, Requirements for Equipments Employing Microelectronic Devices

2.2 Military standards.- The following Military standards, of the issues in effect on date of invitation for bids or request for proposals, form a part of this specification, and are applicable to the extent specified herein:

MIL-STD-785	Requirements for Reliability Program (For Systems and Equipments)
MIL-STD-461	Electromagnetic Interference Test Characteristics Requirements for Equipment
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)

2.3 FAA drawings.- The following FAA drawings form a part of this specification to the extent specified herein:

D-5419-1 through 12, Airport Surveillance Radar, ASR-4 through ASR-7 Tower, Design and Installation Details

2.4 Naval Research Laboratory (NRL) Report.- The following NRL report forms a part of this specification and is applicable to the extent specified herein:

A Guide to Basic Pulse-Radar Maximum - Range Calculation, dated December 23, 1969

2.5 FAA standard.- The following FAA standard of the issue specified in the invitation for bids or request for proposals forms a part of this specification:

FAA-STD-013	Quality Control Program Requirements

Copies of this specification and other applicable FAA specifications, standards, and drawings may be obtained from the Contracting Officer in the Federal Aviation Administration office issuing the invitation for bids or request for proposals. Requests should fully identify material desired, i.e., specification, standard, and drawing numbers and dates. Requests should cite the invitation for bids, request for proposals, or the contract involved or other use to be made of the requested material. Information on obtaining copies of Federal specifications and standards may be obtained from General Services Administration offices in Atlanta; Auburn, Washington; Boston; Chicago; Denver; Fort Worth; Kansas City, Mo.; Los Angeles; New York; and Washington, D. C.

Requests for copies of Military specifications and standards should be addressed to Commanding Officer, Naval Supply Depot, 5801 Tabor Ave., Philadelphia, Pa. 19120.

Copies of the NRL report may be obtained from the National Technical Information Service, Springfield, Virginia 22151. The accession number is AD 701-321.

3. REQUIREMENTS

3.1 Definitions

3.1.1 Principal azimuth plane.- The principal azimuth plane is a plane which includes (1) the line of maximum radiation from the antenna, and (2) an intersecting horizontal line which is normal to the line of maximum radiation. This definition assumes the antenna to be in the normal operating position.

3.1.2 Principal elevation plane.- The principal elevation plane is a vertical plane passing through the center of the reflector and including the line of maximum radiation from the antenna in its normal operating position.

3.1.3 Local and remote.- The words "local" and "remote" used herein refer to the transmitter/receiver site and air traffic control/indicator sites, respectively.

3.1.4 Preheat.- In this specification, preheat refers to those circuits and functions which must be energized, sequenced, and stabilized before the transmitter high voltage may be applied.

3.1.5 Radiating and standby channels.- The radiating or active channel is defined as the channel connected to the antenna. The standby channel is the channel connected to the RF dummy load.

3.1.6 MTI improvement factor (I).- The MTI improvement factor is a power ratio which is defined as $I = r_o/r_i$ where r_o is the output ratio of target to clutter and r_i is the target-to-clutter ratio at the input to the receiver, averaged overall target speeds.

3.1.7 Subclutter visibility (SCV).- The subclutter visibility (SCV) of a radar system is a measure of its ability to detect moving-target signals superimposed on clutter signals. A radar with 20 db SCV, for example, can detect an airplane flying over clutter whose signal return is 100 times stronger.

3.2 Service conditions.- The service conditions shall be those given in 1-3.2.23 of FAA-G-2100/1. Ambient conditions shall be as follows: Environment II, except antenna assembly and associated equipment which shall be Environment III. The equipment shall operate from three-phase, four-wire AC line. The design center value shall be 208V phase-to-phase, 120V phase to neutral.

3.3 System performance and basic design.- In addition to meeting all individual requirements specified herein, the complete system shall perform and be designed and fabricated in accordance with subparagraphs hereunder.

3.3.1 System description.- The radar transmitter/receiver subsystem shall be a solid state, pulse modulated radar operating in the 2.7 to 2.9 GHz band. Digital MTI, capable of operation in both a staggered and an unstaggered mode, shall be provided. A dual high-low beam antenna (3.8, 3.9) shall be provided to extend low-angle coverage and improve short range signal-to-clutter ratio. Circular polarization and log receivers are specified to improve operation under adverse weather conditions. Capability for simultaneous operation of both channels in a dual frequency diversity mode (3.13) is required. Digital video enhancers (3.14.3) for both MTI and normal video shall be provided to improve signal-to-noise ratio. Modular construction shall be employed throughout the system to the extent practicable to facilitate maintenance. Solid state design shall be employed throughout the system. Except for the transmitter output tube, cathode ray tubes. modulator and TR tube, use of vacuum tubes will require the express, written permission of the Contracting Officer.

3.3.2 System coverage.- A demonstration of system coverage by means of a flight check is not required; in lieu of this, the contractor shall prove the required maximum coverage by means of calculations. These calculations shall be furnished prior to acceptance of the first system. Calculations, utilizing measured system parameters except for the constants provided herein, shall be performed in accordance with NRL Report 6930, "A Guide to Basic Pulse - Radar Maximum - Range Calculation", dated 23 December 1969. Such calculations shall indicate detection of a target of one square meter radar cross section with a probability of detection of 0.8 at a range of 55 nautical miles. The target is assumed to be at the nose of the low-beam radiation pattern; the radar is assumed to be operating in linear polarization and with a single channel radiating. Swerling Case 1 target fluctuation and 10^{-6} false alarm probability shall be assumed. Format for the calculations shall be the work sheet on page 94 of the Blake report. Supporting calculations and individual measured parameters shall be included.

3.3.3 System performance characteristics.- The following parameters summarize the characteristics of the system, and are the minimum acceptable; improvements in certain areas may be required due to system losses, etc., in order to provide the coverage of 3.3.2. These characteristics are for single channel operation.

Transmitter

Transmitter peak power (at antenna side of diplexer)	1 MW
Pulse width	0.6 ± 0.05 us
Average PRF	1030 PPS
Radiated frequency	2700-2900 MHz

Receiver

Noise Figure (measured at antenna side of circulator)		4.0 dB
Minimum Discernible Signal (MDS)		
Normal receiver		-110 dBm
MTI receiver		-108 dBm
Normal log receiver		Not more than 1.0 dB below the normal linear receiver
MTI log receiver		Not more than 2.0 dB below linear MTI receiver

Antenna	Main (low) Beam	Passive (high) Beam
Power Gain, relative to isotropic source	33.5 dB min.	32.5 dB min.
Azimuth Beamwidth, principal azimuth plane, -3 dB	1.35° min.	1.35° min.
Elevation Beamwidth, -3 dB	4.8° min.	4.8° min.

Polarization - Selectable, vertical circular

Rotation Rate - 12.5 RPM

MTI System

Dual digital cancellers with feedback

MTI improvement factor	34 dB
Subclutter visibility	28 dB
First true blind speed (stagger operation)	800 knots

3.3.4 System interface.- The system shall interface locally with radar beacon equipment; land lines up to 20,000 feet in length; or a microwave link capable of transmitting video in a broad band mode. Remote control of the system is required. Video line compensators shall be provided for use with land line remoting.

3.3.5 System operation.- Continuous, unattended operation of the T/R subsystem over the range of the service conditions (3.2) is required.

3.4 Equipment configuration and operating modes.-

3.4.1 Configuration.- The standard T/R subsystem shall be a complete dual channel facility with both channels working into a common antenna. The equipment may be installed in a transportable or a fixed type building, neither of which is specified herein. The transportable building is in actuality two half buildings, each half being approximately 12 feet wide by 40 feet long, and with the two halves joined along the long side. The T/R equipment shall incorporate design features to facilitate installation of one of the dual channels in each half of the transportable building, and to readily connect the two channels together into a complete dual channel facility. Such features include but are not limited to a junction box for each T/R channel for termination of all interchannel wiring, a common junction box for connection of wiring to associated equipments and the outside world, etc. The fixed building will provide roughly the same floor space as the transportable building. The contract schedule will specify whether a fixed or transportable building is to be employed; in either case, the contractor shall submit his proposed equipment layout to the Government at the time specified in the contract schedule for review and approval by the contracting officer.

3.4.2 Antenna tower.- The radar antenna shall be designed to be compatible with the ASR tower design presently in use by the Government, and described by FAA drawing series D-5419, sheets 1 through 12. Any proposed changes to this tower design shall be submitted to the Government, together with justification therefore, for review and approval.

3.4.3 Operating modes.- The capability to operate both channels simultaneously into a common antenna in a frequency diversity mode shall be provided (3.13). Staggered PRF shall normally be employed. It shall be possible, however, to remove either channel from the antenna and terminate it into a dummy load by actuation of a single control function. Likewise, it shall be possible on a system basis to operate on an unstaggered PRF by actuation of a single control function. When in the unstaggered mode of operation, the PRF shall be determined by any one of the staggered periods as set up by wire strap or similar semi-permanent means. The entire set of staggered periods shall be variable as specified in 3.14.1 by changing the basic clock frequency. Radiating frequencies and PRFs for each system will be furnished to the contractor at least 120 days prior to delivery.

3.5 Reliability and Maintainability Programs.- The contractor shall plan and implement reliability and maintainability programs in accordance with MIL-STD-785 and MIL-STD-470, respectively. The programs shall be modified as noted herein to meet the detail requirements of this specification as delineated by the reliability, maintainability, and availability requirements stipulated herein.

The ASR reliability shall be such that, in conjunction with achievement of the maintainability requirement, the ASR availability requirement shall be met. Maximum utilization shall be made of standard parts, microcircuits and semiconductors with proven reliability histories. No part or element of the equipment shall be applied so that rated stresses are exceeded under any combination of operating and environmental conditions specified herein. Standard parts are those parts designated in the FAA-G-2100 series of documents. Nonstandard parts (NSPs) are those parts not called out in the FAA-G-2100 documents.

Where nonstandard parts are demonstrated to be necessary in the design, approval must be secured from the contracting officer. Such approval might require the complete qualification of the device, item or part if insufficient historical data and usage warrants it.

The ASR shall be designed to be maintained with a minimum of external test equipment and with standard hand tools. Corrective maintenance shall be effected to the maximum extent possible by replacement of defective modules or PC cards with subsequent repair of the defective items off-line. Requirements for adjustments shall be kept to a minimum. The design shall maximize interchangeability and minimize the need for tuning and/or adjustment. Every attempt shall be made to limit the variety of modules, PC boards, etc., used in the system through design standardization techniques.

3.5.1 Definitions applicable to Section 3.5 - The reliability, availability, and maintainability definitions used in this specification are those of MIL-STD-721B with additions or modifications as noted below:

Mean-time-to-restore (MTTR) - The mean time to restore to an operational condition a function that has failed. The function may be restorable by corrective maintenance repair, substitution of module or board replacement, or redundancy takeover.

Availability - The probability of specified operability at any instant in time over the service life of the equipment. For purposes of this specification, the availability shall be such that during any three (3) months interval, the maximum unavailability shall not exceed 25% of the mean unavailability, where unavailability equals (1-availability). Allowed preventative maintenance times shall not be counted as unavailable periods provided the requirement to reach an operable state is always met.

Mean-time-to-repair - As defined by MIL-STD-721 except that from the mean repair times generated during the maintainability demonstration the maximum at the upper 90 percentile or higher shall not exceed three (3) times the mean.

Service life - Intended minimum useful life of equipment. Short life items are replaced on a scheduled basis under the preventative maintenance plan.

3.5.2 Failures.- ASR failures fall into two categories: functional failures and equipment failures.

3.5.2.1 Functional Failures.- Functional failures are those failures which cause either the complete or partial loss of a functional capability.

3.5.2.2 Equipment failures.- Equipment failures are "black box", module, card, or part failures whose impact upon the system functions may vary from a minor maintenance action to catastrophic. For example, the failure of a power supply whose redundant unit takes over automatically with no system down time is only an equipment failure. However, the random or catastrophic failure of an antenna or antenna pedestal which terminates all RF transmissions is both an equipment and functional failure.

3.5.3 Reliability Program

3.5.3.1 Program plan.- The contractor shall prepare and submit for approval, a reliability program plan in accordance with MIL-STD-785. The reliability program plan shall be submitted with the technical proposal and updated within 90 days after award of contract.

3.5.3.2 Reliability management.- The contractor shall have one clearly identified organizational element which will be responsible for the planning and management of the reliability program specified herein and for insuring its effective execution. The individual designated as head of this reliability management organization shall have the necessary authority and resources, and report at a level having full responsibility for the contract effort to enable him to implement and enforce the requirements specified herein.

3.5.3.3 Program tasks.- The reliability program shall include all the elements of MIL-STD-785 with the following tasks modified as indicated in the paragraphs that follow.

3.5.3.3.1 Design Reviews.- The reliability program plan shall include design reviews of the T/R subsystem, its functions and equipment. They shall include as a minimum, but not necessarily be limited to, a conceptual or preliminary design review and a critical (predesign release to manufacturing) design review. Other reviews may be called as necessary either by the contractor or the Government. The Government shall participate in all reviews. These reviews shall be scheduled as part of the T/R subsystem design reviews. The contractor shall notify the Government of any design reviews at least ten (10) working days prior to their occurence and submit complete data packages at time of notification. Items to be covered as a minimum in the conceptual and critical reviews are the tasks that follow.

3.5.3.3.2 Reliability (availability) apportionment task.- The contractor shall apportion the availability requirements of each constituent component of the T/R subsystem. The constituent components shall, as a minimum, be considered as "black boxes" or modules encompassing singular functions or operations only, i.e., amplifier, control flip-flop, regulator, shift register, etc. These apportionments shall be such that they will be in agreement with the functional reliability requirements specified herein. Apportionments to at least the unit level shall be submitted in the technical proposal and shall be availability requirements of the contractor's design. Periodic refinements of the apportionment shall be submitted as the design progresses.

Any changes in these apportionments shall be submitted to the Government for review and approval. The approval of any reliability apportionment does not release the contractor from the requirement of meeting the functional availabilities specified herein.

3.5.3.3.3 Reliability Modeling Task.- The T/R subsystem shall be reliability modeled and shall identify critical items or paths whose failure will either cause subsystem failures, major performance degradation, marginal operational conditions or departures from the reliability performance characteristics designated herein. From the reliability prediction and the reliability model together with T/R subsystem operational demands, critical elements shall be highlighted and pinpointed with emphasis upon means of sustaining operation, via techniques such as redundancy, overcapacity and alternate routing, etc., in the event of failure. Note, however, that the ability to sustain or reinstate operation in this manner shall not prevent the incident from being classified as a failure.

3.5.3.3.4 Failure Modes, Effects Analysis and Criticality (FMECA) Task.- An FMECA shall be performed. This analysis shall be conducted down to the level of modular replacement in normal maintenance (e.g., printed circuit card, power supply module). For each such replaceable item, the dominant modes of failure shall be determined. Based upon these modes of failure, the effect on subsystem performance shall be ascertained. The analysis results shall be employed to evaluate and change the reliability-maintainability-availability (R-M-A) model, if necessary. The task shall be completed prior to the critical design review and used in preparation of the maintainability demonstration tasks. The task shall be completed and reviewed at the critical design review and used in preparation of the maintainability demonstration tasks. A preliminary analysis utilizing the derived RMA model shall then be submitted ninety (90) days after contract award and updated thereafter as design changes occur.

3.5.3.3.5 Reliability Analysis and Predictions Task.- Reliability analysis and predictions shall be performed for each element of the RMA model. Detailed reliability stress analysis shall be performed in accordance with RADC Reliability Notebook, Volume I, Chapter 9, Paragraph 8 (TR-67-108) (AD-845304). The employment of failure rate data shall be from RADC Notebook, Volume II (TR-67-108) (AD-821640). No other source of failure rate data shall be employed without prior approval of the contracting officer. As part of the detail analysis, part application stress analysis including part local temperatures shall be performed. The failure rate assignments shall be based upon these stress and temperature analyses. FAA-G-2100 Environment II fixed ground, room ambient temperature of 25°C shall be used for the analysis. Additionally, the average part and board temperature shall be estimated based upon the analysis of the attendant thermal environment. The contractor shall also perform measurements on a sample basis as a minimum including at least 10% of boards and parts to verify these stress and thermal analyses. Special parts or devices, i.e., transmitting tubes, power supplies, rotary joints, modulators, etc., shall be part of the critical design review. A preliminary reliability estimate

Any changes in these apportionments shall be submitted to the Government for review and approval. The approval of any reliability apportionment does not release the contractor from the requirement of meeting the functional availabilities specified herein.

3.5.3.3.3 Reliability Modeling Task.- The T/R subsystem shall be reliability modeled and shall identify critical items or paths whose failure will either cause subsystem failures, major performance degradation, marginal operational conditions or departures from the reliability performance characteristics designated herein. From the reliability prediction and the reliability model together with T/R subsystem operational demands, critical elements shall be highlighted and pinpointed with emphasis upon means of sustaining operation, via techniques such as redundancy, overcapacity and alternate routing, etc., in the event of failure. Note, however, that the ability to sustain or reinstate operation in this manner shall not prevent the incident from being classified as a failure.

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Sufficient data shall be included in the summaries to verify the relevant/nonrelevant classification. That is, maintenance induced, operator error, accidental are examples of some reasons for justifying the nonrelevancy classification.

3.5.4 Maintainability Program

3.5.4.1 Program Plan.- The contractor shall prepare and submit for approval a maintainability program plan in accordance with MIL-STD-470 in its entirety, except as modified by this specification. The program plan shall include a milestone chart including program review points, design reviews, and analyses and predictions, and maintainability demonstration. The maintainability program plan shall be included with the system program plan documentation submitted with the technical proposal and updated ninety (90) days after award of contract.

3.5.4.2 Maintainability management.- The contractor shall have one clearly identified organizational element which will be responsible for planning and managing the maintainability program. The individual designated as head of this maintainability organization shall have necessary authority and resources and report at a level having full contract responsibility. The maintainability organization may be part of the reliability organization as delineated in paragraph 3.5.3.2.

3.5.4.3 Program Tasks.- The maintainability program shall include, but not be limited to, the following tasks.

3.5.4.3.1 Maintainability Apportionment.- The system availability apportionment shall be allocated as maintainability requirements, in consonance with the reliability apportionment to subsystems and major assemblies of the ASR constituting elements of the RMA model. These maintainability equipment apportionments shall be firm requirements but the contractor shall retain the flexibility to meet T/R subsystem requirements. These apportionments shall be such that, when achieved, the T/R subsystem availability requirements are met.

The initial allocation shall be submitted as part of the technical proposal and shall be refined and reviewed at the scheduled design reviews.

3.5.4.3.2 Failure Modes and Effects Analysis (FMEA).- In the performance of the FMEA, as described in paragraph 3.5.2.1 above, the effects of corrective maintenance action shall be evaluated. In the event that performance of corrective or preventive maintenance, such as replacement of a failed circuit card or module, affects an otherwise operable or functioning circuit, this effect shall be included in the RMA model.

<u>3.5.4.3.3 Maintainability Analysis and Predictions</u>.- Maintainability analysis and predictions shall be performed for each element of the RMA model. Maintainability analysis shall be in accordance with paragraph 5.2, MIL-STD-470. Predictions of mean corrective maintenance time shall be performed in accordance with Procedure II, Part B, Corrective Maintenance, MIL-HDBK-472.

Preventive maintenance requirements shall be determined and the schedule, procedure, and the estimated duration of each preventive maintenance task shall be reported as part of the maintainability prediction results. However, preventive maintenance shall be limited to nonpeak traffic hours totalling not more than 15 hours a month in increments not exceeding 1 hour in any one day and shall be accomplished with shutdown of only those elements not required to maintain system operational capability as required by traffic conditions. Any preventive maintenance time which exceeds either the 15 hours per month or 1 hour per day shall be considered as corrective maintenance and counted as down time if it causes the function to be out of commission. Further, when required, the portions of the system down for preventive maintenance shall be capable of being brought into an on-line operational state within 1 hour. The design shall, to the extent possible, optimize the reliability/maintainability through the proper selection of parts, derating and redundancy. Preliminary prediction results shall be submitted in the RMA Analysis and Prediction Report and updated thereafter as design or system changes require and additional data are obtained. Predictions shall be reviewed as part of each design review. Final submission shall be 45 days prior to initiation of the maintainability demonstration.

<u>3.5.4.2.4 Maintainability Demonstration</u>.- A maintainability demonstration of achievement of the specified mean and maximum corrective maintenance times shall be performed as specified in Section 4.

<u>3.5.5 Reliability and Maintainability Numerical Requirements</u>.- The ASR system shall meet the following reliability and maintainability requirements.

a.	Simple ASR radar MTBF (exclusive of antenna)	1000 hours
b.	Dual ASR radar availability	0.999
c.	MTTR	1 hour
d.	Dual ASR MTBF (exclusive of antenna)	10,000 hours
e.	Antenna MTBF (including all ancillary items, i.e., rotary joints, slip rings, encoders, etc.)	10,000 hours

<u>3.6 Summary of equipment furnished by contractor</u>.- The contractor shall furnish the quantity of ASR Transmitter/Receiver subsystems specified in the contract. Any item or part necessary for proper operation and adjustment in accordance with the requirements of this specification shall be

incorporated even though that item or part may not be specifically provided for or described herein. All features required to meet performance requirements, such as shock mounting of particular modules or assemblies, heat circulation by means of blowers, controls, indicator lamps, overload protection devices, meters, test points, interlocks, switches, etc., shall be incorporated even though the features may not be specifically provided for, or described herein. All necessary facilities, parts, and hardware, including receptacles, connectors, cabling (wiring), adapters and outlets shall be incorporated to enable the components of the system to be properly assembled, interconnected, installed, and maintained as required herein. Each T/R subsystem shall be complete and in accordance with all specification requirements, and shall include the following major items (all other items not listed below, but required for system operation, testing, or adjustment in accordance with the requirements of this specification shall also be furnished):

a.	1 each	Control Assembly (3.15 and subparagraphs)
b.	1 each	Antenna Assembly (3.8 through 3.9)
c.	1 set	Azimuth Position Data Equipment (3.8.9 and subparagraphs)
d.	1 lot	Waveguide (3.12 and subparagraphs)
e.	1 set	Waveguide Switches (3.12.5)
f.	2 each	RF Dummy Loads (3.12.6)
g.	2 each	Transmitter/modulator assembly (3.10 and subparagraphs)
h.	2 each	Receiver assembly (3.11 and subparagraphs)
i.	2 each	Processor assembly (3.14 and subparagraphs)
j.	1 lot	Ducts, Cabling, Hardware, etc.
k.	1 set	Junction Box Panels and Junction Boxes (3.15.2.1)
l.	4 each	Remote Control Panels and Boxes
m.	1 each	Maintenance PPI (3.16.1 and subparagraphs)
n.	1 set	Special Tools (1-3.16.23, FAA-G-2100/1)
o.	1 lot	Intercommunications Equipment (3.16.4)

3.7 Documentation furnished.- Documentation specified in subparagraphs hereunder shall be furnished at the time(s) specified in the contract schedule, in addition to that required by FAA-G-2100/1 or other subsidiary specifications.

3.7.1 Instruction manuals.- Instruction manuals in accordance with FAA-D-638 as modified herein (3.16.3 and subparagraphs) shall be furnished in the quantity and at the times specified in the contract schedule.

3.7.2 Trouble shooting manuals.- Trouble shooting manuals (3.16.3 and subparagraphs) shall be furnished in the quantity and at the times specified in the contract schedule.

3.7.3 Power consumption.- The contractor shall provide the Government with information as to the normal operating and peak power consumption of the T/R subsystem. Power consumption of the antenna shall be listed separately from the electronic equipment.

3.7.4 Required floor space and weight.- The contractor shall provide the Government with floor space requirements and floor loading of the T/R subsystem on a per cabinet and total basis. Size and weight of the antenna shall also be furnished.

3.7.5 Required test equipment.- The contractor shall provide the Government with a list of required test equipment (3.13.5).

3.7.6 Remoting cables.- The contractor shall furnish the Government with information as to the quantity and recommended types of interconnecting land lines required for complete operation of the T/R subsystem from a site located up to 20,000 feet away.

3.7.7 Revision of documentation.- It is recognized that completely accurate information of the type called for in paragraphs 3.7.3 through 3.7.6 above may not be available at the time of original submission. The contractor shall advise the Government of any changes to this data as soon as design refinements permit, and shall provide final, accurate data no later than 120 days prior to scheduled delivery of the first system. Revisions and corrections to instruction manuals and trouble shooting manuals shall be in accordance with FAA-D-638.

3.8 Antenna assembly.- The antenna shall include a mounting pedestal, dual drive mechanism, five path rotary joint, a main transmit/receive feed horn, a passive receive only feed horn, reflector, dual azimuth data system, circular/linear polarizers, and other features described herein needed to comply with the requirements of this specification. The antenna design shall meet all requirements herein while operating under the conditions of Environment III, paragraph 1-3.2.23, FAA-G-2100 except that the wind conditions shall be 0-85 knots operational, with the upper limit extended to 130 knots nonoperational.

3.8.1 Basic antenna design requirements.- The antenna system described herein shall be designed to be mounted atop an antenna tower without a radome. Since the antenna assembly is not dual channel and, therefore, does not have an operating standby, extreme care shall be exercised in its design to assure that it is the strongest link in the radar system. The design shall minimize antenna maintenance to the greatest possible extent. The antenna system shall be designed to facilitate removal and replacement of any portion of the antenna system except the antenna reflector and pedestal without the need of a crane or other equipment not furnished as a part of the radar system.

3.8.1.1 MTI performance.- The antenna shall be designed to operate satisfactorily in conjunction with an MTI system. Vibration of the antenna in the direction of the beam shall not exceed 1/64 inch, and vibration in a rotational direction shall not exceed 0.015° in order not to degrade the MTI improvement factor due to scanning to less than 40 dB. The figures are for total motion between transmitter pulse intervals with the antenna rotating and radiating.

3.8.1.2 Ease of maintenance.- The antenna assembly shall be constructed so as to be easy to disassemble for maintenance and repair. A simple hoist which can be placed on the maintenance platform and operated by not more than three technicians shall be furnished for major maintenance in lowering and raising the heavy and/or large items between the maintenance platform and the ground. Provisions shall be made to completely disassemble and remove mechanical parts which are subject to wear or deterioration without removal or diassembly of the reflector, feed horns, or any supporting structures. Design shall include provisions for routine inspection of critical internal pedestal and drive mechanism parts without disassembly.

3.8.2 Antenna mechanical design requirements.- The antenna shall be designed to meet the following requirements.

3.8.2.1 Maximum rotational speed.- The antenna assembly shall be designed to withstand rotation rates up to 20 rpm without structural failure. While operating under conditions specified herein, the position of the feed horn relative to the reflector and the deviation of the reflector surface contour from the true (design) contour shall not result in azimuthal error greater than 0.2 degree or vertical error greater than 0.1 degree of the maximum power point of the radiated beam from the correct position. These requirements shall be met with an FA-7202, or equal, beacon antenna mounted in position atop the radar antenna reflector without requiring beacon antenna mounting readjustments.

3.8.2.2 Provision for tilting.- The antenna tilt shall be continuously adjustable from the antenna platform so that the lower -3 dB power point of the linearly polarized main beam can be set at any angle between -2.5° and $+2.5^{\circ}$ with respect to horizontal without any interference between the tilt screw, antenna pedestal, antenna reflector and supports, tower platform, waveguide or any other components with the antenna rotating.

3.8.2.2.1 Tilting mechanism.- The tilting mechanism shall be manually operable over its entire range in a period of two minutes by one technician. Mechanical stops shall be provided to limit the travel of the reflector in the vertical plane at the upper and lower limits of the tilting mechanism. A positive lock shall be provided to prevent slipping at any tilt adjustment. The engagement and disengagement of the lock may require a technician to be on the antenna platform.

3.8.2.2.2 Tilt indicator.- A mechanical tilt marker shall be located on the reflector or reflector support. A calibrated scale providing angular readings in increments of 0.1° shall be provided to indicate the antenna electrical tilt. The marks indicating increments of 0.1° and the spacing between shall be easily distinguished. The tilt indicator shall show the tilt of the -3 dB power point of the main beam to an accuracy of 0.1° at 2800 MHz. A means of checking the tilt indicator accuracy against a readily determined physical tilt of the antenna reflector shall be provided.

3.8.2.2.3 Tilt chart.- A permanent weather-proof type graph or chart shall be attached to each reflector assembly in a conspicuous location to permit correction of the tilt indicator for frequency. The scale of this graph or chart shall be sufficient to determine the electrical tilt to an accuracy of 0.1° from 2700 to 2900 MHz. This accuracy shall be verified for at least two frequencies during antenna testing.

3.8.2.3 Safety switch.- A safety switch shall be provided for the antenna tower. This switch shall directly open both primary power to the antenna drive motors and transmitter high voltage. It shall be designed and located so that access to the antenna platform of the antenna tower structure cannot be gained without first opening the safety switch. Deliberate manual action shall be required to operate the safety switch. It shall not be operated by closing the access door, or subject to accidental operation. The safety switch contacts shall be designed to carry the full starting current of the antenna drive motors so that it may be actuated and deactuated without damage. An antenna on-off switch, separate from the safety switch, shall be incorporated on the underside the antenna platform near the antenna drive safety switch and brake release; the operation of this switch or the safety switch shall disable the transmitter connected to the antenna. The antenna rotation shall be capable of being turned on and off by either the switch at the designated point of control (3.15.1.1) or by the control switch under the antenna platform. These two switches shall operate independently of each other; neither, however, shall be capable of overriding the safety switch when it is open.

3.8.2.4 Castings.- Antenna assembly load bearing castings shall be inspected by nondestructive methods such as radiography, magnafluxing, fluorescence, or ultrasonic vibration methods.

3.8.2.5 Antenna balance.- With a beacon antenna mounted on the radar antenna and the radar antenna set for a $+1^{\circ}$ electrical tilt, the center of gravity of the rotating portion of the antenna shall be within six inches of the center of azimuth rotation along the radiation axis. Along the axis perpendicular to the radiation axis, the center of gravity shall be within three inches of the center of azimuth rotation. This condition shall be obtained without the use of counter weights totalling in excess of 50 pounds.

3.8.2.6 Vibration and noise.- Vibration, or noise, or both, from the antenna assembly shall not interfere with the performance or stability of electronic components in the equipment building. The noise level as measured at a distance of 5 feet directly below the antenna pedestal with the antenna rotating at 12.5 RPM shall not exceed the limits of Condition A, paragraph 1-3.5.11 of FAA-G-2100/1.

3.8.2.7 Leveling.- Mechanical jacks, or wedges, or similar devices shall be provided to level the antenna pedestal as installed on the tower. For leveling purposes, two accessible liquid bubble levels mutually perpendicular or a circular bubble level shall be mounted on the rotating portion of the antenna pedestal. The sensitivity of the bubbles shall permit leveling of the antenna to within 0.1°. Leveling of the antenna following initial installation, other than that required by settling of the tower foundation, shall not be required.

3.8.3 Test antenna.- A test antenna shall be provided with each antenna system. A mounting fixture and appropriate sized removable section of the reflector shall be provided so that the test antenna can be placed in an optimum position from behind the reflector. The antenna shall be suitable for measuring the transmitter output power and to permit circular polarization measurements. It shall be possible to accurately rotate the test antenna by $\pm 90^{\circ}$ in 1° increments utilizing the mounting fixture, and to read the antenna position. The test antenna shall be furnished with a directional coupler and dummy load for use in measuring the transmitting power. Antenna balance (3.8.2.5) shall be obtained with the test antenna removed.

3.8.4 Mounting pedestal.- The mounting pedestal shall support the reflector (including beacon antennas), polarizer, feed horns, drive mechanisms, azimuth position generators, and RF rotary joint and other items required for system operation. The pedestal shall be designed to mount on the upper deck of the antenna tower, but shall extend below the deck to facilitate the mounting and maintenance of the drive units, azimuth data package, rotary joint and other ancillary units from the maintenance platform. The design shall permit routine and minor maintenance and lubrication of the pedestal and drive mechanisms by one technician at the maintenance platform level while the system is operating. Exposed portions of the pedestal shall be weather resistant and dust tight. All supported components shall be easily accessible for servicing without requiring major disassembly of the reflector or other components. The mounting pedestal shall support and rotate the antenna assembly under the service conditions specified in such a manner that the total cumulative effect of vibrations in the mounting pedestal, horn assembly and supports, and antenna on the RF characteristics shall not exceed the limits specified herein. In addition, the mounting pedestal shall not allow error in the apparent position of the RF beam to exceed 0.1°.

3.8.4.1 Slip ring assembly.- A slip ring assembly, including sufficient circuits to satisfy all requirements stated in this specification plus six spares, each capable of handling 120 volts, 5 amps. 60 Hz, shall be provided. The slip ring assembly shall be reliable and easily adjustable with a useful slip ring brush life of at least 25,000 hours operation without adjustment. Terminal strips shall be provided to terminate both ends of the slip ring connections. The slip ring assembly may be an integral part of the rotary joint, but must be readily accessible for maintenance or replacement.

3.8.4.2 Pedestal overhaul.- The pedestal shall not require any maintenance that would require removal of the assembly from the antenna tower more often than every five years. Provisions shall be made for supporting the rotating portions of the antenna to allow disassembly of components from the pedestal. It shall be possible to replace the main bearing and bull gear in three hours or less (including removal of the rotary joint if required) without disassembly of the reflector or removal of the pedestal from the tower.

3.8.4.3 Lubrication.- Oil level check, fill, overflow, and drain plugs, all accessible from the maintenance platform, shall be included. The design shall be such that lubrication and oil level checks may be accomplished without stopping antenna rotation or turning the transmitter high voltage off. Lubrication shall not be required more frequently than once each 4,000 hours of actual operation. The pedestal shall be designed to preclude oil entering the rotary joint, slip ring assembly, or waveguide.

3.8.4.4 Azimuth indication.- Azimuth indication of the antenna shall be provided by a ring attached to the rotating member of the pedestal by means of positioning clamps or screws. The ring shall have legible, permanent marks for every degree and each ten degree increment shall be numbered. An indicating device for the antenna azimuth ring shall be located in an accessible position on a fixed member of the pedestal and shall be clearly visible from the maintenance platform. Provisions shall be made for 360° orientation of the azimuth ring with respect to the antenna.

3.8.4.5 Braking provisions.- A manually operated brake shall be provided to hold the antenna stationary. When the brake is set, an electrical interlock shall prevent application of power to the antenna drive motors until the brake is released. The brake shall be operable from the maintenance platform. The brake shall be adjustable to compensate for wear and to establish a desired braking pressure. Application of the brake with the antenna rotating shall not place undue stress on either the radar or beacon antenna.

3.8.4.6 Factory run-in test.- A 168 hour factory run-in test shall be conducted on each pedestal and installed rotary joint with a load applied that adequately simulates the antenna operating under normal test conditions. Type test antennas shall, in addition, be run for 24 hours under worst combinations of environmental conditions in order to determine any mechanical difficulties that may exist. Measurements of power input variation, temperature rise of critical parts of the pedestal and drive mechanisms, observations of noise and vibration and oil leakage, azimuth data accuracy, and other pertinent data shall be recorded for each unit during this factory test.

3.8.5 Drive mechanism.- Two separate drive mechanisms shall be employed. Each antenna drive mechanism shall consist of a drive motor, gear train, slip clutch, and mechanical linkage to the rotating portion of the pedestal. The antenna shall rotate continuously in a clockwise direction through 360° in the horizontal plane at a speed of 12.5 rpm ± 10% over the service conditions specified. Rotation rate under normal test conditions shall be 12.5 rpm + 5% - 0%. Each drive motor shall employ a separate contactor, and the design shall be such that one drive mechanism may be disengaged by shutting down the antenna for 60 seconds or less. It shall be possible to replace the failed drive from the underside of the pedestal while the system is in operation. The replaced drive shall be capable of being re-engaged by shutting down the antenna for a maximum of two minutes. Each drive mechanism shall have separate pinion gears, and shall mount on opposite sides of the main bull gear (on a line passing through the center of rotation). Both drive mechanisms are normally energized; if either drive unit should lock or other failure occur, it shall automatically disengage and the standby unit shall drive the antenna. Each drive unit shall be capable of starting and driving the antenna under all extremes of service conditions except for wind, which shall be 40 knots.

3.8.5.1 Drive motor protection.- Each antenna azimuth drive motor shall contain a thermostat adjusted so that no damage occurs to the motor during a temporary overload or locked rotor. This thermostat shall be in thermal contact with the motor winding and shall be accessible without complete disassembly of the motor.

3.8.6 AC power receptacle.- Convenience outlets (1-3.6.4, FAA-G-2100/1) with weather tight covers shall be provided on the antenna pedestal and on the lower portion near the drive units. The power energizing the outlets shall be independent of the antenna rotation on-off switch and the antenna safety switch.

3.8.7 Reflector.- The reflector shall be secured to the antenna frame in such a manner as to produce a positive mechanical and electrical bond to eliminate RF arcing between the reflector and frame. The reflector shall be suitably contoured to provide the radiation pattern specified. The reflector shall not exceed those dimensions in length and height which are required to meet the specified electrical performance. Supports and trusses for the reflector and feed system shall not interfere with the electrical performance of the assembly.

3.8.7.1 Contour deflection.- The design and fabrication of the reflector shall be such that deviation of the surface contour from the true (design) contour shall not exceed ± 1/4 inch under maximum static load. Under dynamic load (12.5 rpm, 85 knots wind) the deviation from the static curvature shall not exceed ± 3/8 inch at center and ± 3/4 inch at tips, and the deviation in radial distance from focal point to top of reflector in the symmetrical center line vertical plane shall not exceed ± 1/2 inch the true (design) distance. The contour deflection requirements shall be met with the beacon antennas installed and rotating at 12.5 rpm. The removable section of the reflector surface utilized for the test horn shall be removable from the rear and shall not distort the reflector contour when in place to the extent that antenna performance is affected.

3.8.7.2 Contour jigs, fixtures, templates.- All templates used for inspecting the reflector contour shall be made of metal. The jigs, fixtures, templates, or other devices used to fabricate and check the antenna contours shall be subject to approval of the Government and shall become the property of the Government upon completion of fabrication of the last antenna reflector on the contract.

3.8.7.3 Field check provisions.- Equipment and data for alignment and for checking the position of the feed horn and the reflector contour for possible field damage shall be provided with each antenna.

3.8.7.4 Beacon antenna provisions.- The structure of the reflector shall be designed to permit the installation of an FA-7202 or equivalent beacon directional antenna and an FA-7205 or equivalent omni-directional (SLS) antenna. Mounting provisions shall be supplied for both beacon antennas. The design shall permit field installation of the beacon antennas with the radar antenna reflector in place on top of the tower. The beacon antennas are to be mounted above the radar antenna reflector in such a position that negligible derogation of either the beacon antenna radiation patterns or the radar antenna radiation pattern result and so that all other specification requirements except balance (3.8.2.5) are achieved, either with the beacon antennas mounted or not mounted in position. A coaxial cable (RG-218/U) with waterproof connectors shall be supplied for connecting the output of each beacon section of the rotary joint to the input of the beacon antennas.

3.8.7.4.1 Beacon directional antenna provisions.- Mounting provisions shall be provided for the beacon directional antenna. The beacon directional antenna is to be mounted on top of the radar antenna reflector.

3.8.7.4.1.1 Antenna support pads.- The support pads shall accept the beacon directional antenna mounting as shown in Figure 1. Provisions shall be made to permit easy disconnect of the coaxial connector at the beacon directional antenna to allow testing of the cable without the necessity of removing the beacon directional antenna or changing the support alignment. There shall be no mechanical interference between the antenna structures.

3.8.7.4.1.2 Radar/beacon directional antenna alignment.- The structural rigidity of the beacon antenna support pads shall be such that while operating at 12.5 rpm, the maximum power point of the azimuthal radiated beam of the beacon directional antenna shall be no more than 0.1 degree from the correct position of the maximum power point of the azimuthal radiated beam of the primary radar.

3.8.7.4.1.3 Beacon antenna tilt.- The mounting pads for the beacon directional antenna shall be level when the radar antenna is set for 0° electrical tilt.

3.8.7.4.1.4 Antenna weight.- The total weight of the beacon directional antenna will not exceed 340 pounds. The structure of the radar antenna shall be capable of supporting this load under all extremes of the service conditions.

3.8.7.4.2 Mounting provisions for beacon omni-directional (SLS) antenna.- The SLS antenna is to be mounted on top of the radar antenna and to the rear of the beacon directional antenna. The base of the SLS antenna shall be level with the top of the beacon directional antenna.

3.8.7.4.2.1 Antenna support flange.- The support flange shall accept the SLS antenna mounting flange which is a flat circular metal plate six inches in diameter. The support flange shall contain four mounting studs equally spaced on a 4.750 inch bolt circle. The studs shall be 3/8 inch diameter, 1-1/2 inch long (N.S.) (threaded full length - 16 UNC-2A). Mounting nuts

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3.8.7.4.1.3 Beacon antenna tilt.- The mounting pads for the beacon directional antenna shall be level when the radar antenna is set for 0^{o} electrical tilt.

3.8.7.4.1.4 Antenna weight.- The total weight of the beacon directional antenna will not exceed 340 pounds. The structure of the radar antenna shall be capable of supporting this load under all extremes of the service conditions.

3.8.7.4.2 Mounting provisions for beacon omni-directional (SLS) antenna.- The SLS antenna is to be mounted on top of the radar antenna and to the rear of the beacon directional antenna. The base of the SLS antenna shall be level with the top of the beacon directional antenna.

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3.8.9 Azimuth position data system.- The azimuth position data system shall include devices on the antenna to generate azimuth data and the necessary amplification and processing circuitry to interface with other equipments at the transmitter and remote sites.

3.8.9.1 Dual system requirement.- The azimuth position data system shall be composed of two complete and separate systems. The azimuth data systems shall consist of two separate azimuth pulse generators, two separate line driver pulse amplifiers, two separate shaper amplifiers, and two separate power supplies. These redundant azimuth data sources shall operate independently such that failure or removal of one unit shall not interfere with proper operation of the other unit. One generator shall be directly coupled to the rotating portion of the antenna without use of gears; the other shall be driven through a gear train of only one gear mesh. Either generator shall be removable without interfering with the operation of the other.

3.8.9.2 Reliability of operation.- The azimuth pulse generation components of the antenna assembly shall be designed for continuous and reliable operation. Preventive maintenance, including lubrication and adjustment, shall not be required more frequently than once each 8,000 hours of actual operation. Replacement of parts or overhaul requiring more than one hour antenna downtime shall not be required more frequently than once every five years of actual operation. The number of electronic components located at the antenna pedestal shall be kept to an absolute minimum. Where replacement of modules or of the complete unit with a spare can be made in less than 10 minutes antenna downtime with subsequent bench overhaul, the replacement or overhaul interval may be reduced to once every three years of actual operation.

3.8.9.3 Azimuth pulse generators.- The azimuth pulse generator shall generate 4096 pulses and one reference pulse for each rotation of the antenna. The pulse-to-pulse jitter of the azimuth change pulse shall be no greater than ±10% of the nominal spacing, and the azimuth reference pulse jitter shall be no greater than ±20% of the azimuth change pulse spacing. The output characteristics of azimuth change pulses and the azimuth reference pulse derived from the antenna pedestal mounted APG shall be as follows:

(a) Azimuth Change Pulses (ACPs): A series of 4096 pulses generated for each 360 degree rotation of the antenna. An output waveform approximating a sine wave is acceptable.

(b) Azimuth Reference Pulse (ARP): A single pulse, as one ARP, for each 360 degree rotation of the antenna. An output waveform approximating a sine wave is acceptable. The ARP shall be generated midway between two ACPs.

(c) Pulse Amplitude (ACPs and ARP): At least 3 volts peak on positive-going excursions.

(d) Output isolation: Separate output connectors shall be provided for the ACP and ARP signals. Isolation between outputs, including hum and noise, shall be 40 dB or more.

The APG shall employ an optical encoder and solid-state light source. The above characteristics shall be met when measured at the ends of RG-59/U for any cable length up to 300 feet when terminated in 75 ohms.

3.8.9.4 Azimuth accuracy.- The azimuth pulse shall indicate by pulse count the angular position of the center of the radar beam as determined by the position of the rotating portion of the antenna pedestal, with an angular error not to exceed $\pm 0.088^{\circ}$. Provisions shall be made for setting the ARP to any angle with respect to the antenna.

3.8.10 Antenna materials and finish.- The antenna assembly shall utilize materials, coatings and finishes which are inherently resistant to the corrosive (smog) environments found at many airport sites. As a minimum, the reflector and back structure shall be fabricated from aluminum or other inherently corrosion resistant material (not steel). Other portions of the antenna assembly shall also be of corrosion resistant materials to the maximum extent possible. Any portions of the antenna assembly other than those specifically allowed by paragraph 1-3.15.1 of FAA-G-2100/1, shall not be fabricated from steel unless express written approval is obtained from the contracting officer.

All exposed metal surfaces of the antenna assembly shall be protectively coated using the following three finishes:

1. Zinc chromate wash primer per MIL-C-8514, thickness .0002 to .0003 inches.

   OR

   Chemical film per MIL-C-5541, Type I or II, Grade C, Class 3.

2. Epoxy primer per MIL-P-23377 or equivalent, thickness .0007 inches max.

3. Polyurethane Enamel per MIL-C-38412, Type II, color international orange, color number 12196 per Fed. Std. 595, thickness .0014 to .0018.

This paragraph modifies Section 1-3.8 of FAA-G-2100/1 for the antenna only.

3.9 Antenna RF characteristics.- The RF characteristics of the antenna shall meet all performance requirements over the complete range of frequencies from 2700 to 2900 MHz without substitution of components or adjustments. The antenna shall produce a single transmit pattern, a receive pattern identical to the transmit pattern, and a second receive pattern at a higher elevation angle to provide short-range coverage having a higher signal-to-clutter ratio. The second pattern shall be generated by an additional receive-only feed horn (passive feed horn) placed under the conventional transmit/receive feed horn (main feed horn). The requirements specified below are given in terms of one-way power for a linear polarized mode of operation unless otherwise specified.

3.9.1 Power gain.- The gain of the antenna pattern associated solely with the main feed horn in the direction of maximum radiation and reception shall be a minimum of 33.5 dB relative to an isotropic source. The gain of the antenna pattern associated solely with the passive feed horn in the direction of maximum reception shall be 32.5 dB relative to an isotropic source. The insertion loss of the antenna pattern selector shall not be included in this measurement.

3.9.2 Voltage standing wave ratio.- The voltage standing wave ratio (VSWR) for the overall antenna, with the feed horns in place and matched to the antenna reflector, when measured at the input of the waveguide running between the rotary joint and the polarizer, shall not exceed 1.3 for either antenna feed path in either the vertical or circular positions of the polarizers. In addition, the voltage standing wave ratio of the feed path associated with the main feed horn shall not exceed 1.4 during the transition of the polarizer when switching between linear and circular polarization. Overall VSWR measurements shall be taken continuously over the frequency range of 2700 to 2900 MHz. The measurements shall be made for the optimum setting of the polarizers to cover the complete frequency band. Distorting the waveguide or the addition of dielectric material to individual sections of the RF system to correct the VSWR will not be allowed.

3.9.3 Power handling capacity.- The power handling capacity of the vertical/circular polarizer, feed horn, and all interconnecting waveguide on the antenna for the main feed horn path shall be at least 1.25 MW peak at 0.0007 duty cycle. The same feed horn path shall have a power handling capability of 2.5 MW peak at 0.0007 duty cycle with pressurization. The power handling capability of the vertical/circular polarizer, feed horn, and all interconnecting waveguide on the antenna for the passive feed horn path shall be adequate to handle without pressurization the maximum power received by the passive feed horn by reflection or mutual coupling of the radiated energy of the main feed horn transmitting 2.5 MW peak power at 0.0007 duty cycle.

3.9.4 Azimuth relative field strength patterns.- The relative field strength of the antenna pattern associated with the main feed horn shall have the following characteristics. The azimuth beamwidth in the principal azimuth plane shall be 1.35° minimum at -3 dB and 4° maximum at -20 dB. From the underside -6 dB power point of the principal elevation plane pattern to 10° in elevation above the principal azimuth plane, the azimuth beamwidth with respect to the maximum power at the same elevation shall be 1.35° minimum at -3 dB and 4° maximum at -17 dB. From 10.1° to 20° in elevation above the principal azimuth plane, the azimuth beamwidth with respect to the maximum power at the same elevation shall be 1.35° minimum at -3 dB and 5.0° maximum at -17 dB. From 20.1° to 30° in elevation above the principal azimuth plane, the azimuth beamwidth with respect to the maximum power at the same elevation shall be 1.35° minimum at -3 dB and 5.5° maximum at -15 dB. From the underside -6 dB power point of the principal elevation plane pattern to 30° in elevation above the principal azimuth plane, the midpoint of each -10 dB beamwidth shall fall within 0.10° of the midpoint of its respective -3 dB beamwidth. Similarly, the midpoint of each -15 dB, -17 dB, or -20 dB beamwidth, whichever is specified above, shall fall within 0.20° of its respective -3 dB beamwidth. The relative field strength of the antenna pattern associated with the passive feed horn shall have the following characteristics. The azimuth beamwidth in the principal azimuth plane shall be 1.35° minimum at -3 dB and 4.4° maximum at -20 dB. From the underside -20 dB to -15.1 dB power points of the principal elevation plane pattern, the azimuth beamwidth with respect to the maximum power at the same elevation angle shall be 1.1° minimum at -3 dB and 3.0° maximum at -10 dB. From the underside -15.0 dB to -6.1 dB power points of the principal elevation plane pattern, the azimuth beamwidth with respect to the maximum power at the same elevation angle shall be 1.2° minimum at -3 dB and 4.0° maximum at -15 dB. From the underside -6.0 dB power point of the principal elevation plane pattern to +10° in elevation above the principal azimuth plane, the azimuth beamwidth with respect to the maximum power at the same elevation angle shall be 1.35° minimum at -3 dB and 4.4° maximum at -17 dB. From +10.1° to +20.0° in elevation above the principal azimuth plane, the azimuth beamwidth with respect to the maximum power at the same elevation angle shall be 1.35° minimum at -3 dB and 5.5° maximum at -17 dB. From +20.0° to +28° in elevation above the principal azimuth plane, the azimuth beamwidth with respect to the maximum power at the same elevation angle shall be 1.35° minimum at -3 dB and 6.0° maximum at -15 dB. From the underside -20 dB to -15.1 dB power points of the principal elevation plane pattern, the midpoint of each -10 dB point shall fall within 0.20° of the midpoint of its respective -3 dB beamwidth. From the underside -15 dB power point of the principal elevation plane pattern to 28.0° in elevation above the principal azimuth plane, the midpoint of each -10 dB beamwidth shall fall within 0.10° of the midpoint of its respective -3 dB beamwidth. Similarly, the midpoint of each -15 dB, -17 dB, or -20 dB beamwidth, whichever is specified above, shall fall within 0.20° of its respective -3 dB beamwidth.

3.9.4.1 Azimuth side lobes.- An azimuth side lobe will be considered to be any lobe not in the back lobe sector. The side lobe levels are specified with respect to peak power in the plane in which the pattern measurement is made. The azimuth side lobes of the antenna pattern associated with the main feed horn shall be down not less than 24 dB in the principal azimuth plane, down not less than 20 dB at +10° above the principal azimuth plane, down not less than 17 dB at +30° above the principal azimuth plane, and down not less than 20 dB at the angle below the principal azimuth plane equal to the 6 dB down point of the principal elevation plane pattern. The azimuth side lobes at other intermediate elevation angles shall be down at least to the extent that their dB values are equal to or greater than that required for them to have a direct linear relationship to the elevation angles between the angle of the underside 6 dB down point of the principal elevation plane and the principal azimuth plane (from -20 dB to -24 dB); to the elevation angles between the principal azimuth plane and +10° above the principal azimuth plane (from -24 dB to -20 dB); and to the elevation angles between +10° above the principal azimuth plane and +30° above the principal azimuth plane (from -20 dB to -17 dB). The azimuth plane side lobes of the antenna pattern associated with the passive feed horn shall be not more than 2 dB greater than those specified for the main feed horn. In addition, the azimuth plane side lobes of the pattern associated with the passive feed horn shall be down not less than 13 dB at the angle below the principal azimuth plane equal to the -20 dB point of the principal elevation plane. The azimuth side lobes at underside elevation angles between the -20 dB and the -6 dB points of the principal elevation plane shall be down at least to the extent that their dB values are equal to or greater than that required for them to have a direct linear relationship to the elevation angles between these two points (from -13 dB to -18 dB).

3.9.5 Elevation relative field strength patterns.- The relative field strength of the antenna pattern associated with the main feed horn in the principal elevation plane shall have the following characteristics. The elevation beamwidth at -3 dB shall be 4.8° minimum. Above the upper half power point, the relative field strength pattern shall be a smooth curve starting at the upper -3 dB point and described in terms of dB down from the maximum power of the principal elevation plane pattern at elevation angles above the principal azimuth plane as follows: 6 dB down at 6°, 9.5 dB down at 12°, 11 dB down at 18°, 12 dB down at 25°, and 15 dB down at 30°. The allowable departure from the above pattern shall be plus no limit and minus 1.0 dB. At an angle of 4.1° below the underside -3 dB power point, the power shall be down not less than 20 dB below the maximum power in the principal elevation plane. Any side lobe on the underside of the beam shall be down not less than 22 dB below the maximum power of the principal elevation plane pattern. The relative field strength of the antenna pattern associated with the passive feed horn in the principal elevation plane shall have the following characteristics. The elevation beamwidth at -3 dB shall be 4.8° minimum. Above the upper half power point, the relative field strength pattern shall be a smooth curve starting at the upper -3 dB point and described in terms of dB down from the maximum power of the principal elevation plane pattern at elevation angles above the principal azimuth plane as follows: 6 dB down at 6°, 9.5 dB down at 12°, 11 dB down at 18°, 12 dB down at 25°, and 15 dB down at 28°. The allowable departure from the above pattern shall be plus no limit and minus 1.0 dB. At an angle of 5.1° below the underside -3 dB power point, the power shall be down not less than 20 dB below the maximum power in the principal elevation plane. Any side lobes on the underside of this pattern shall be down not less than 20 dB below the maximum power of its respective principal elevation plane pattern.

3.9.6 Back radiation.- The back radiation for the patterns associated with the main feed horn and those associated with the passive feed horn shall be down not less than 33 dB below the nose of their respective secondary beams (back radiation shall be considered to be any radiation in the hemisphere of space bounded between the angles from 90° to 270° to the direction of maximum field strength of the secondary beams).

3.9.7 Separation between the main and passive feed horn antenna patterns.- The axis of maximum field strength associated with the passive feed horn antenna pattern shall be elevated above the axis of maximum field strength for the antenna pattern associated with the main feed horn by an angle that will result in the underside principal elevation plane field strength of the pattern associated with the passive feed horn falling 14 dB $\pm$ 1 dB below the field strength of the underside -3 dB power point of the principal elevation plane pattern associated with the main feed horn. The midpoint of the 3 dB power points of any azimuth plane pattern contained within the specified principal elevation plane pattern for the antenna patterns associated with the main and passive feed horns shall not differ from the midpoint of the 3 dB power points of the principal azimuth plane antenna pattern associated with the main feed horn by more than 0.1°.

3.9.8 Horizontal polarization component.- When operating with vertical polarization, the cross (horizontal) polarization component of the antenna for both feeds shall be at or below the same level specified for the vertically polarized side and back lobes within the angular region applicable to these lobes and down not less than 18 dB from the peak of the vertical polarization pattern in the same azimuth plane within the angular region covered by the vertically polarized main lobe.

3.9.9 Directional beam squint, frequency.- The midpoint of principal azimuth plane pattern associated with the main feed horn shall remain within $\pm 0.1^{\circ}$ over the frequency range of 2700 to 2900 MHz with respect to the midpoint at 2800 MHz. The underside 3 dB point on the principal elevation plane associated with the main feed horn shall remain within $\pm 0.2^{\circ}$ over the frequency range of 2700 to 2900 MHz with respect to the underside 3 dB point at 2800 MHz.

3.9.10 Vertical/circular polarization.- The antenna system shall be designed to provide for both vertical and circular polarization of the RF signals. The antenna feeds shall have the same sense circular polarization. It shall be possible to meet or exceed the specification performance requirements without changing either polarizer adjustments after initial settings. The design of the polarizers shall be such that the transmitter HV may be left on during the transition from LP to CP and vice versa. The design of the polarizer associated with the main feed horn shall provide for the orthogonal circular polarizer signal being connected in the normal fashion to the polarizer dummy load, with a provision for reconnecting it in the field to a suitable coaxial female connector for use as a weather data output source. The axis of maximum relative field strength for vertical polarization of the antenna for either feed shall not differ from the axis of relative field strength for the vertical components of circular polarization by more than 0.1° in the principal azimuth plane and 0.2° in the principal elevation plane.

3.9.11 Phase disturbance due to polarization switching.- The design of the circular polarization feeds and switching assemblies shall be such that when the radar system is adjusted for optimum operation in either the vertical or circular mode, switching to the other mode will not derogate the MTI performance. This requirement does not apply for transient conditions that may exist during the period while the actual switching is taking place.

3.9.12 Integrated cancellation ratio (ICR).- The integrated cancellation ratio of the antenna for the patterns associated with the main feed horn and the passive feed horn shall be at least 22 dB as measured in the principal elevation plane. The ICR of the antenna for the patterns associated with the main feed horn and passive feed horn shall be at least 22 dB in the principal azimuth plane, 17 dB at the elevation angle of the underside -6 dB one-way power strength, 17 dB at an elevation angle of 5° above the nose of the elevation pattern, 10 dB at an elevation angle of 30° above the nose of the elevation pattern for the main feed horn and 28° above the nose of the elevation pattern for the passive feed horn. In addition, the ICR shall be at least 8 dB in the azimuth plane at the elevation angle of the underside -20 dB one-way power strength of the pattern associated with the passive feed horn. The dB value of ICR for azimuth antenna patterns for both the passive and main feed horns at other elevation angles shall be equal to or greater than that required for them to have a direct linear relationship of dB versus angle between each of the points specified. All of the above requirements shall be met over the frequency band from 2700 to 2900 MHz without making any adjustments on the vertical/circular polarizers and feed horns from the one fixed set of adjustments required for the best overall integrated cancellation ratios.

<u>3.9.13 Antenna pattern tests</u>.- The contractor shall furnish a detailed description of the proposed test procedure to measure both the vertical and circular polarization patterns specified in the foregoing paragraphs. In addition, he shall present evidence that the test site is sufficiently free from ground reflections to make ICR measurements to an accuracy of ± 1 dB when measuring ICR values up to 22 dB. Continuous pattern recording equipment shall be used to record the pattern data. The following subparagraphs furnish additional information concerning the techniques to be used in performing some of the pattern measurements.

<u>3.9.13.1 Vertical polarization pattern tests</u>.- With the polarizers set for vertical polarization, the contractor shall perform the following tests at 2700, 2800, and 2900 MHz.

a. With the antenna turned on its side, measurements shall be made of the principal elevation plane patterns between 15° below the principal azimuth plane to 35° above the principal azimuth plane. The following azimuth plane measurements shall be made: The principal azimuth plane pattern, the azimuth plane pattern at the underside -6 dB point on the principal elevation plane, and the azimuth plane patterns at $+10^{\circ}$, $+20^{\circ}$, and $+30^{\circ}$ (28° in lieu of 30° for the pattern associated with passive feed horn) above the principal azimuth plane. The azimuth plane patterns shall be measured between 10° to the left and 10° to the right of the maximum power point in the same plane. The above measurements shall be made for patterns associated with the main feed horn and for those patterns associated with the passive feed horn. Azimuth plane pattern measurements shall also be made at the underside -20 dB and -15 dB points on the principal elevation plane pattern for the patterns associated with the passive feed horn. These patterns shall be measured between 10° to the left and 10° to the right of the maximum power point in the same plane. All azimuth plane pattern measurements above the principal azimuth plane shall be made with the antenna mounted upside down. All azimuth patterns measured below the principal azimuth plane shall be made with the antenna mounted upright.

b. With the antenna turned on its side, the principal elevation plane pattern shall be made for the 360° of rotation for the antenna patterns associated with the main feed horn and with the passive feed horn. With the antenna mounted upright and the principal azimuth plane of the pattern associated with the main feed horn tilted up 2.5° above horizontal, the antenna shall be rotated 360° in azimuth and pattern measurements made in the plane perpendicular to the axis of rotation for the antenna patterns associated with the main feed horn and the passive feed horn. The principal azimuth plane pattern in the vicinity of the peak should be superimposed on these patterns to serve as a reference to measure the side lobe and back lobe levels.

c. In addition to the above, for the type test antennas only, azimuth plane patterns shall be made at +5°, +15°, and +25° above the principal azimuth plane. These patterns shall be measured between 10° to the left and right of the maximum power point in the same plane. Measurement of the complete 360° of rotation shall be made for the type test antennas in such a manner as to record the relative field strength of the patterns associated with the main feed horn and with the passive feed horn that would be seen if the principal azimuth plane associated with the main feed horn were tilted up 2.5° above horizontal and the antenna was viewed in 5° intervals from elevation angles from +5° above the plane perpendicular to the axis of rotation to +10° above that elevation angle between the top of reflector and the middle of the passive feed horn.

d. The antenna patterns have been specified based on antenna test facilities that use an antenna mount with an elevation axis above the recording azimuth axis. The azimuth beamwidth measurements shall be adjusted mathematically to provide identical data as would be obtained on a mount with an elevation axis above the recording azimuth axis in the event that a different type of mount is used to make the pattern measurements.

3.9.13.2 Circular polarization pattern tests.- Integrated cancellation ratio measurements and calculations shall be made for those patterns associated with the passive feed horn and the main feed horn. For these measurements the polarizers shall be set for circular polarization. The following is a description of a method of measuring ICR acceptable to the Government. Any other method the contractor may wish to use shall be subject to Government approval.

a. The radar antenna to be tested is to be used as a receiving antenna situated in the far-zone field of a transmitter antenna. The transmitter antenna shall be a parabola at least 10 feet in diameter capable of being continuously rotated mechanically about its electrical axis to change the angle of transmitted polarization. A principal azimuth plane pattern is to be recorded on a graph as the plane of polarization of the transmitting antenna is rotated sufficiently slow to permit accurate tracking by the pattern recorder. The antenna under test shall be simultaneously rotated in the horizontal plane sufficiently slow that recorded ellipticity cycles are close

b. With the antenna turned on its side, the principal elevation plane pattern shall be made for the 360° of rotation for the antenna patterns associated with the main feed horn and with the passive feed horn. With the antenna mounted upright and the principal azimuth plane of the pattern associated with the main feed horn tilted up 2.5° above horizontal, the antenna shall be rotated 360° in azimuth and pattern measurements made in the plane perpendicular to the axis of rotation for the antenna patterns associated with the main feed horn and the passive feed horn. The principal azimuth plane pattern in the vicinity of the peak should be superimposed on these patterns to serve as a reference to measure the side lobe and back lobe levels.

c. In addition to the above, for the type test antennas only, azimuth plane patterns shall be made at +5°, +15°, and +25° above the principal azimuth plane. These patterns shall be measured between 10° to the left and right of the maximum power point in the same plane. Measurement of the complete 360° of rotation shall be made for the type test antennas in such a manner as to record the relative field strength of the patterns associated with the main feed horn and with the passive feed horn that would be seen if the principal azimuth plane associated with the main feed horn were tilted up 2.5° above horizontal and the antenna was viewed in 5° intervals from elevation angles from +5° above the plane perpendicular to the axis of rotation to +10° above that elevation angle between the top of reflector and the middle of the passive feed horn.

d. The antenna patterns have been specified based on antenna test facilities that use an antenna mount with an elevation axis above the recording azimuth axis. The azimuth beamwidth measurements shall be adjusted mathematically to provide identical data as would be obtained on a mount with an elevation axis above the recording azimuth axis in the event that a different type of mount is used to make the pattern measurements.

<u>3.9.13.2 Circular polarization pattern tests</u>.- Integrated cancellation ratio measurements and calculations shall be made for those patterns associated with the passive feed horn and the main feed horn. For these measurements the polarizers shall be set for circular polarization. The following is a description of a method of measuring ICR acceptable to the Government. Any other method the contractor may wish to use shall be subject to Government approval.

a. The radar antenna to be tested is to be used as a receiving antenna situated in the far-zone field of a transmitter antenna. The transmitter antenna shall be a parabola at least 10 feet in diameter capable of being continuously rotated mechanically about its electrical axis to change the angle of transmitted polarization. A principal azimuth plane pattern is to be recorded on a graph as the plane of polarization of the transmitting antenna is rotated sufficiently slow to permit accurate tracking by the pattern recorder. The antenna under test shall be simultaneously rotated in the horizontal plane sufficiently slow that recorded ellipticity cycles are close patterns and where θ is the elevation angle measured downward from vertical of the point on the beam being measured, assuming that the nose of the beam associated with the main feed horn is tilted upward at an angle 2.5° above horizontal.

3.9.13.3 Other antenna tests.- In addition to the above measurements, measurements shall be made to demonstrate compliance with the requirements of paragraphs 3.9.1, 3.9.2, 3.9.3, 3.9.7, 3.9.8, 3.9.9, 3.9.10, and 3.9.11. Where appropriate, these measurements may be recorded in conjunction with the measurements specified under paragraphs 3.9.13.1 and 3.9.13.2.

3.10 Transmitter-modulator assembly.- The transmitter-modulator cabinets shall include all high voltage and other power supplies (focus, heater), the modulator and its associated driver and power supply(s), RF driver, klystron output tube and any control or other auxiliary equipment necessary to meet all applicable requirements specified herein. General construction, electrical characteristics and performance shall be in accordance with subparagraphs hereunder.

3.10.1 Physical size.- The transmitter-modulator circuitry shall be housed in not more than two cabinets of the height and depth and not exceeding twice the width specified in paragraph 3.18.1. Alternately, separate cabinets whose combined size does not exceed that of the cabinets specified above may be employed if X-ray or RF shielding, cooling or other considerations indicate that multiple cabinets are preferable. If multiple cabinets are employed, critical RF and high voltage signals may be routed directly through the interconnecting walls by means of appropriate feed-throughs; all non-critical signals, power, etc., interconnections and connections to other system cabinets or junction boxes shall be at the tops of the cabinets as specified in paragraph 3.18.1.

3.10.2 Transmitter general requirements.- The general characteristics of the transmitter and the transmitted pulse shall be as specified in subparagraphs hereunder.

3.10.2.1 Operating frequency.- The transmitter shall be capable of operating at any frequency from 2700 to 2900 megahertz, inclusive. The operating frequency shall be determined by crystal controlled sources. The two channels of a system shall operate on frequencies separated as required to permit the system to perform in a dual frequency diversity mode (3.13). The Government will assign frequencies for each system, and will advise the contractor of the frequencies selected at least 120 days prior to scheduled delivery of the system.

3.10.2.2 RF pulse duration.- The duration of the transmitted RF pulse shall be 0.6 ± 0.05 microseconds as measured between the half power points.

3.10.2.3 Stability.- The summation of system instabilities, including the contribution of the transmitter modulator, shall result in system MTI performance meeting all requirements specified herein.

3.10.2.4 RF pulse spectrum.- At frequencies separated from the assigned carrier frequency by ± 10 megahertz or more, the radiated power shall be down at least 40 dB with respect to the power radiated at the assigned carrier frequency.

3.10.3 Transmitter output tube.- The transmitter shall employ a multi-cavity klystron amplifier, continuously tunable over the assigned frequency band (2700 - 2900 MHz). At any frequency within this band, the tube shall simultaneously exhibit a minimum instantaneous bandwidth at the minus 0.5 dB points of 15.0 MHz, a minimum gain of 50 dB, and a minimum RF transmit efficiency of 45% while transmitting a minimum peak power of 1250 KW at a duty cycle of 0.00072. Normal operating peak power shall be 1 MW at a duty cycle of 0.00063. The tube shall employ an indirectly heated cathode. The high-voltage beam power supply shall be adjustable to permit adjustment of the output power level. Features shall be incorporated to provide automatic control of the beam voltage at a low value when the supply is first turned on, then to increase to a pre-set level. When the supply is turned off, the voltage shall automatically run down. The klystron "body" shall operate at ground potential. The heater voltage shall be adjustable. Current limiting shall be incorporated in the heater supply to limit the turn-on surge current to 150 percent of normal operating current. Failure of the heater supply shall automatically turn off the beam power supply.

3.10.3.1 Beam focusing.- The klystron beam focusing shall be accomplished by the use of a single electromagnetic coil, mechanically separate from the klystron tube assembly. The electromagnetic coil shall be driven from a separate, variable power supply. The power shall be adequately filtered so that the ripple will not result in amplitude and/or phase modulation of the RF output signal.

3.10.3.2 Transmitter cooling.- The klystron and focusing magnet shall be cooled by means of forced air. The cooling system air flow shall be adequate to dissipate the entire beam power with RF drive removed up to a maximum altitude of 6,000 feet msl and a maximum temperature of 40°C. Ducts to the building exterior shall be provided for both air intake and exhaust. External air shall automatically be selected whenever external temperature falls within the range of 0°C to 20°C; at other times interior circulation shall be employed. Manual selection of either internal or external air shall be possible. All exterior ducts shall be filtered. The noise level of the cooling system shall not exceed the limits of paragraph 1-3.5.11 of FAA-G-2100/1. Air flow and over temperature interlocks shall be provided to protect the transmitter-modulator assembly.

3.10.3.3 Output window.- The klystron output window shall be maintained near ambient temperature, and shall be capable of withstanding pressurization as specified in 3.12.

3.10.3.4 VSWR.- The klystron shall meet all performance requirements while operating into a 1.2:1 load mismatch and shall operate without damage into a 1.5:1 mismatch. The tube shall withstand a mismatch of 3.0:1 for 15 milliseconds without damage.

3.10.3.5 Mechanical features.- The klystron cavity body structure, cathode/heater, electron gun structure, collector structure, and cavity tuning mechanism shall be of integral construction and separate from the beam focusing electromagnet assembly. It shall be possible to install and remove the klystron assembly without necessitating disassembly or removal of the focus electromagnet assembly. For purposes of tube installation and replacement, features shall be incorporated for positive positioning of the tube in vertical, lateral, and rotational dimensions. Correct "seating" of the tube shall also accomplish correct and positive connection for the cathode and heater. The klystron output-to-systems waveguide adaptor shall an integral part of the tube assembly.

3.10.3.5.1 Tuning.- Individual cavity tuning mechanisms shall be provided to permit tuning when the klystron is in its normal operating position. Each control shall also incorporate a digital tuning indicator visible when tuning. Chart(s) shall be furnished plotting tuning indicator versus frequency. The tuning torque shall not exceed 500 inch ounces.

3.10.3.5.2 Ease of maintenance.- The mechanical design of the transmitter system shall assure ease of maintenance of any transmitter component, including the klystron. Any special equipment (such as a hoist required for removal of the klystron) shall be provided. Design shall be such that complete removal and replacement of the klystron and restoration of normal operation can be accomplished in not more than two hours by not more than two people.

3.10.3.6 Getter and ion pump.- The klystron shall incorporate an ion pump which shall operate continuously when the tube is operating. If the tube manufacturer recommends operation of the ion pump during tube storage, this capability shall be provided.

3.10.4 Metering.- Metering shall be provided for high-voltage, heater voltage, focus coil voltage, and all critical currents to monitor tube operation. The metering circuits shall incorporate features to preclude erroneous indications resulting from the environment in which they operate. Metering circuits shall be protected in the event of faulty high current conditions.

3.10.5 Arc protection.- To protect the klystron from arcing which may occur in the system waveguide, an arc detector shall be incorporated in the system waveguide to initiate removal of the RF drive.

3.10.6 X-radiation shielding.- X-ray shielding shall be provided as required to reduce the radiation to a safe level for personnel working in the vicinity for prolonged periods of time. The shielding shall also be sufficient to permit a safe environment for klystron adjustments and tuning. A maximum safe level is defined as an exposure capability of 2.0 milliroentgens per hour (1-3.5.4, FAA-G-2100/1).

3.10.7 Transmitter modulator.- The transmitter modulator shall be solid state except that the final stage may be either solid state or a ceramic thyratron. In either case, the modulator shall be modular and possess a fail-soft characteristic in that operation at reduced power is possible following failure of a module. The rise and fall times and duration of the modulator pulse shall be such as to insure that it completely brackets the RF drive pulse to the output tube, while simultaneously holding the input power drain to a minimum. The modulator shall be capable of providing at least 20% more power than is required to produce the normal transmitter output power (3.10.3).

3.10.7.1 Stagger operation.- The modulator shall be capable of operation at a staggered, non-uniform pulse repetition frequency (PRF) as specified in 3.14.1.1. For either the staggered or unstaggered mode of operation, performance of the modulator shall be consistent with the MTI performance specified in 3.10.2.3, as well as all other system performance requirements.

3.10.7.2 Modulator dummy load.- A high power modulator dummy load shall be supplied as part of each transmitter unit for testing the radar modulators. The principal function of this equipment shall be to dissipate all the energy generated by the radar modulator under test so that it can be tested independently of the output tube. The circuit shall consist of a non-inductive resistor or resistors. The power dissipation rating and input impedance shall be consistent with the high voltage modulator output. The voltage dividing ratio shall be 100 to 1 for the video connection.

3.10.7.3 Interlocks.- All high voltage portions of the transmitter/modulator cabinet shall be fully enclosed, with all access doors fully protected by interlock switches which cannot be bypassed.

3.10.8 Transmitter high-voltage (HV) power supply.- The HV power supply shall be capable of delivering at least 20% more than the average power required to supply the RF output tube with its normal rated power (3.10.3). Fail-safe provisions shall be included to automatically discharge any high-voltage capacitors which might endanger the safety of personnel. Electronic regulation circuitry shall be provided to assure operation during stagger operation consistent with specified MTI performance (3.10.2.3) and all other applicable requirements.

3.10.8.1 Voltage adjustment.- The voltage output of the HV power supply shall be controlled by a continuously-variable device having a calibrated control. The output voltage adjustment range shall be sufficient to change the transmitter RF output power over the range of at least from 400 KW to 1.15 MW. An adjustable stop on the control shall prevent the output voltage from exceeding the maximum permissible operating value for the RF output tube.

3.10.8.2 Filtering.- The direct current transmitter high-voltage power supply shall be filtered as required for fulfillment of the MTI system performance requirements of this specification.

3.10.8.3 Inrush current.- With the transmitter high voltage adjusted to result in the maximum power rating of the output tube, it shall be possible to turn the transmitter high voltage off and on repeatedly without equipment damage or actuation of overload protectors and resultant immediate satisfactory system performance even though normal operation will utilize the automatic fail-soft characteristic in that operation at reduced power is possible following failure of a module. The rise and fall times and duration of the modulator pulse shall be such as to insure that it completely brackets the RF drive pulse to the output tube, while simultaneously holding the input power drain to a minimum. The modulator shall be capable of providing at least 20% more power than is required to produce the normal transmitter output power (3.10.3).

3.10.7.1 Stagger operation.- The modulator shall be capable of operation at a staggered, non-uniform pulse repetition frequency (PRF) as specified in 3.14.1.1. For either the staggered or unstaggered mode of operation, performance of the modulator shall be consistent with the MTI performance specified in 3.10.2.3, as well as all other system performance requirements.

3.10.7.2 Modulator dummy load.- A high power modulator dummy load shall be supplied as part of each transmitter unit for testing the radar modulators. The principal function of this equipment shall be to dissipate all the energy generated by the radar modulator under test so that it can be tested independently of the output tube. The circuit shall consist of a non-inductive resistor or resistors. The power dissipation rating and input impedance shall be consistent with the high voltage modulator output. The voltage dividing ratio shall be 100 to 1 for the video connection.

3.10.7.3 Interlocks.- All high voltage portions of the transmitter/modulator cabinet shall be fully enclosed, with all access doors fully protected by interlock switches which cannot be bypassed.

3.10.8 Transmitter high-voltage (HV) power supply.- The HV power supply shall be capable of delivering at least 20% more than the average power required to supply the RF output tube with its normal rated power (3.10.3). Fail-safe provisions shall be included to automatically discharge any high-voltage capacitors which might endanger the safety of personnel. Electronic regulation circuitry shall be provided to assure operation during stagger operation consistent with specified MTI performance (3.10.2.3) and all other applicable requirements.

3.10.8.1 Voltage adjustment.- The voltage output of the HV power supply shall be controlled by a continuously-variable device having a calibrated control. The output voltage adjustment range shall be sufficient to change the transmitter RF output power over the range of at least from 400 KW to 1.15 MW. An adjustable stop on the control shall prevent the output voltage from exceeding the maximum permissible operating value for the RF output tube.

3.10.8.2 Filtering.- The direct current transmitter high-voltage power supply shall be filtered as required for fulfillment of the MTI system performance requirements of this specification.

3.10.8.3 Inrush current.- With the transmitter high voltage adjusted to result in the maximum power rating of the output tube, it shall be possible to turn the transmitter high voltage off and on repeatedly without equipment damage or actuation of overload protectors and resultant immediate satisfactory system performance even though normal operation will utilize the automatic

In the event of loss of primary power for an interval of 15 seconds or less, the system HV shall be capable of being reset without requiring the normal preheat time to recycle.

3.10.10.2 Time delays.- A time delay device shall be incorporated to prevent the application of high voltage to the modulator until the RF output tube and modulator have been properly preheated.

3.10.10.3 Spark gaps.- Spark gaps shall be incorporated to protect components (such as plate transformers, output tube, pulse-forming networks, etc.) from overvoltage. The spark gaps utilized shall be designed to minimize change in characteristics with age or with the number of arc-overs that might occur.

3.10.11 Metering and indicator lamps.- The following meters and indicator shall be furnished as a minimum:

Meters	Indicator Lamps
1. Operate time	1. HV on
2. Transmitter HV	2. Filament on
3. Transmitter HV current	3. Faults
4. Modulator inverse current	4. Fault recycle
5. Transmitter low voltage power supply voltages and currents	5. Modulator driver HV on
6. Thyratron driver current (if thyratron used)	6. Preheat
7. Thyratron driver inverse current (if thyratron used)	7. Transmitter available
8. Klystron current/voltage (3.10.4)	8. No control

3.10.12 Transmitter-modulator pulse monitoring.- Provisions shall be incorporated for viewing, at test jacks, the voltage and current pulses of the pulsed output tube and modulator with calibrated voltage-divider networks and current-viewing transformers.

3.11 Receiver assembly.- The receiver assembly shall include both normal and MTI receiver circuitry, RF plumbing and circuitry common to the normal and MTI receivers, and the RF generator (stalo, coho), all housed in a single cabinet of the type specified in 3.18.1. The receiver assembly shall perform and be designed in accordance with the requirements of sub-paragraphs hereunder and other applicable specification requirements.

3.11.1 Receiver RF components.- RF components common to both the normal and MTI receivers include but are not limited to receiver TR devices, receiver gain control/STC, antenna pattern RF switch, parametric amplifier and wave-guide pre-selector filter. These components shall be in accordance with the following sub-paragraphs and all other applicable specification requirements.

3.11.1.1 TR device.- TR devices shall be employed as necessary to protect the receiver and to insure that the receiver has recovered to within 3.0 dB of its normal sensitivity within 5 microseconds of the firing of the transmitter. The recovery time specified above shall be obtained with the receiver PIN modulator set for minimum attenuation and with the receiver connected to both the passive (high beam) and main (low beam) feed horns. Insertion loss of the TR device shall not exceed 0.5 dB. The TR device shall not require a "keep alive" voltage source, and shall provide full receiver protection from both the transmitter associated with the receiver and the opposite channel transmitter.

3.11.1.2 Receiver gain control/STC.- Receiver RF gain and sensitivity time control (STC) shall be accomplished by means of two PIN modulators inserted in the receive path ahead of the parametric amplifier. Provisions shall be made for remote control of the devices. When biased for minimum attenuation, the maximum insertion loss of each device shall be 0.5 dB; when biased for maximum attenuation, the attenuation of each device shall be at least 40 dB. One such device shall be provided in both the high beam (passive) receive path and the low beam (main) receive path for each channel. The devices shall be installed between the TR device (3.11.1.1) and the antenna pattern RF switch (3.11.1.3).

3.11.1.2.1 Receiver RF gain.- The gain control circuitry shall provide five discrete preset bias levels for the PIN modulator, any of the five pairs of which may be remotely selected. Each bias level shall be adjustable by means of maintenance controls to provide RF attenuation ranging from the minimum insertion loss of the PIN device up to 20 dB. The preset level shall remain constant within ± 0.75 dB over the range of service conditions. This variation shall not add to the insertion loss of 0.5 dB specified in 3.11.1.2.

3.11.1.2.2 Sensitivity time control (STC).- Separate STC control circuitry shall be provided for each PIN modulator. Each STC circuit, by control of the PIN device bias, shall provide three time varying gain characteristics (STC-1, STC-2 and STC-3). Any of these three characteristics, as well as an STC OFF, shall be remotely selectable.

The three STC characteristics shall be generated by three identical, separately adjustable circuits with minimum range of adjustment as follows:

(a) The initial value of receiver attenuation shall be adjustable from the minimum insertion loss of the device to at least 40 dB.

(b) The start of the exponential decrease in attenuation from the initial value shall be adjustable from a minimum of not more than 1 microsecond after the beginning of the transmitted pulse to at least 100 microseconds.

(c) The shape of the attenuation curve shall be adjustable from a characteristic which is inversely proportional to the first power of range to a characteristic which is inversely proportional to the fourth power of range. The maximum attenuation need not exceed the 40 dB level specified above.

The selected STC characteristic shall be combined with the selected preset attenuation level described herein (3.11.1.2.1). The STC characteristic shall not change with changes in the preset attenuation level except that the gain shall not recover beyond the selected preset attenuation level. The STC characteristics shall remain within ± 0.75 dB of their preset levels over the range of the service conditions..

3.11.1.2.3 Receiver blanking.- Receiver suppression in addition to the STC and RF gain previously specified shall be provided as necessary to prevent objectionable evidence of the transmitter pulse in the output videos. This feature shall not affect the receiver recovery time.

3.11.1.3 Antenna pattern RF switch.- A semiconductor RF switch shall be provided for the switching of the RF energy received from the passive feed horn and the main feed horn. The RF switch shall be installed between the RF device used for receiver gain control/STC and the RF amplifier. The actual switching point in radar range where the switching from one feed path to the other takes place will be determined by the antenna pattern selector (paragraph 3.11.1.3.1). The actual switching time, including that part contributed by the antenna pattern selector and its associated drive circuitry, shall be 100 ns maximum. The amount of jitter during the actual switching process contributed by the antenna pattern RF switch and the antenna pattern selector and associated drive circuitry shall be sufficiently small that the MTI performance is not degraded. The insertion loss of the antenna pattern RF switch from either input to the output when terminated in the RF amplifier shall be 0.6 dB maximum. A minimum isolation of 30 dB shall be provided between the two input ports of the switch.

3.11.1.3.1 Antenna pattern selector.- The antenna pattern selector shall initiate the switching action of the antenna pattern RF switch. The point or points in radar range where this switching action is initiated shall be determined by one of the following selectable sources:

(a) An internal switch designated high beam/low beam which will select either the energy received from the passive feed horn (high beam) or the energy received from the main feed horn (low beam).

(b) An internal generated gate that is adjustable from 0 to 60 miles in range, to switch from the high beam to the low beam.

(c) An external input jack -- the presence of a positive going signal of 3.0 volts or greater will switch from the high beam to the low beam; the presence of a negative going signal of 0.5 volts or less will switch from the low beam to the high beam. The range azimuth gate (RAG) will be connected to this input.

3.11.1.4 Parametric amplifier.- A completely solid-state parametric amplifier of the following minimum characteristics shall be provided:

Operating frequency	2.7 to 2.9 GHz
Instantaneous bandwidth (1 dB)	200 MHz
RF Gain (minimum)	15 dB
Input signal for 1 dB compression of output signal	Not less than -30 dBm
Noise figure (maximum)	1.25 dB

Amplitude and phase stability of the parametric amplifier (particularly short term stability) must be adequate to result in the specified system MTI performance. A Gunn diode pump source shall be employed. The parametric amplifier shall be an integrated, three-section, circulator - amplifier assembly and shall provide a minimum of 35 dB active isolation from the antenna pattern selector and the mixer. Temperature stabilization shall employ solid-state, proportional control. The design of the temperature controller shall be fail-safe, in that no mode of failure can result in high temperature burnout of any part of the parametric amplifier. A means of checking for proper operation of the temperature stabilization system shall be provided.

3.11.1.5 Waveguide preselector filter.- A waveguide preselector filter of rectangular waveguide cavity type, shall be installed between the duplexer and signal mixer of the receiver. System performance requirements will be tested and based on location of the waveguide preselector filter after the parametric amplifier. The following requirements shall be met from 2.7 to 2.9 GHz. The bandwidth of the filter shall be approximately 8 MHz at the minus 0.5 dB points (relative to peak) with a maximum of 0.15 dB ripple throughout the passband. The insertion loss at the operating frequency shall be a maximum of 0.75 dB. The attenuation to signals ± 50 MHz from the operating frequency shall be at least 60 dB. The attenuation to signals ± 90 MHz from the operating frequency shall be at least 70 dB. Tuning shall be accomplished by means of accurately calibrated micrometer adjustments. Each filter shall be individually calibrated, and the correct micrometer settings for the complete frequency fange from 2.7 to 2.9 GHz shall be furnished in the form of a permanent graph that is attached to the equipment near the filter in a readily visible location. The micrometers shall be replaceable and the filter shall meet all applicable apecification requirements after one or more of the micrometers are replaced and the filter has been recalibrated. The resetability of the filter shall be such that it shall be possible to repeatedly tune the filter to any operating frequency from 2.7 to 2.9 GHz by reference to the graph and have the operating frequency fall within ± 1.0 MHz of the center of the passband of the filter. When the filter is tuned, the ripple, insertion loss and bandwidth shall be in accordance with the requirements specified above.

3.11.2 Receiver signal mixer.- A balanced diode signal mixer shall be provided. The mixer shall not saturate on any signal that is not saturated in the parametric amplifier. A meter shall be provided to monitor the signal mixer current. The output of the mixer shall be a 30 MHz IF signal, obtained by mixing the received RF signal with the STALO signal (3.11.8.3). The IF output of the mixer shall be essentially free from spurious components that might excite the preamplifier or IF circuits.

3.11.3 Receiver IF frequency.- The center frequencies of all IF amplifiers (linear normal, log normal and MTI) shall fall between 29.8 and 30.2 MHz. Within this range, the center frequencies of all three IF amplifiers shall differ by no more than 0.2 MHz.

3.11.4 Receiver IF preamplifier. An IF preamplifier shall be installed in the signal receiver path following the signal mixer. The preamplifier shall be matched to the signal mixer and located physically close to the signal mixer. The receiver IF preamplifier shall accept the 30 MHz output from the signal mixer and provide the necessary amplification, dynamic range, and bandpass characteristics to drive the linear normal, log normal and MTI IF amplifiers. The preamplifier shall provide isolated outputs for each of the above, plus two spare isolated outputs. Unused outputs shall be properly terminated.

3.11.5 Normal receiver characteristics.- The normal receiver shall consist of a linear IF amplifier and detector.

3.11.5.1 Normal receiver features.- The normal receiver shall accept its separate output from the preamplifier and provide a video output and other operational characteristic as outlined below.

3.11.5.2 IF bandwidth.- The IF bandwidth of the normal portion of the receiver in MHz shall be not less than 1.2 nor greater than 1.4 divided by the pulse width in microseconds.

3.11.5.3 Normal receiver output.- The output of the normal receiver shall be non-limited normal video, with the signal-to-noise ratio adjustable up to a minimum of 8:1. No video ringing, base line modulation or base line level variation shall occur on the video output with variation of input signal strength, even with advancement of gain controls beyond normal levels. Grass (noise) level amplitude shall not decrease with the advance of IF gain control to its upper limit. Dead areas following strong clutter returns shall not occur as a result of IF saturation. There shall be no parasitic oscillations or evidence of instability with any setting of controls. All normal receiver controls, other than the RF gain and STC controls specified in 3.11.1.2 and subparagraphs shall be maintenance type controls. Each normal receiver shall include two isolated 75 ohm outputs, one of which will be used as an input to the combiner, the other of which is a spare.

3.11.6 MTI receiver characteristics.

3.11.6.1 IF amplifier.- Limiting shall take place in the IF amplifier; the limiting characteristic shall not droop more than 10% over a wide range of input signal levels including the strongest returns. The MTI IF limit level shall be adjustable while maintaining a constant noise output amplitude from the phase detector, with a fixed setting of the MTI IF gain control and constant level COHO input to the phase detector. The MTI IF bandwidth shall be sufficient to result in the specified MTI performance for both weak and strong radar returns.

3.11.6.2 Phase detector.- The phase detector characteristic shall be linear for signals below limit level. The output of the phase detector shall possess an essentially linear sawtooth-balanced characteristic with positive and negative amplitudes within 2 dB of each other.

3.11.6.3 Low pass filter.- The output of the phase detector shall be fed to a low pass filter with the bandwidth necessary to achieve proper MTI performance for both weak and strong radar returns, but not less than 1.0 divided by the pulse width in microseconds.

3.11.6.4 IF test pulse generator.- A built-in coherent IF test pulse generator shall be incorporated that will generate a series of test pulses in phase with the transmitter pulse. The series of test pulses shall be generated by a pulsed 30 MHz signal from the COHO. These pulses shall be fed to the MTI system for operation evaluation and adjustment. Gain compensation shall be incorporated in the circuitry to standardize the amplitude of the test pulses to a uniform peak level. Sufficient number of test pulses shall be available to cover a minimum range of 40 miles with pulse spacing not to exceed two nautical miles. Test pulse amplitude shall be sufficient to limit in the IF amplifier at normal operating setting of gain controls. Stability of pulses and extraneous products shall not be limiting factors in measurement.

The IF test pulse generator shall also include a separate, crystal controlled 30 MHz RF pulse generator to simulate random speed (non-coherent) moving targets. The pulse generator shall be capable of being triggered by an external voltage greater than +3.5 VDC (nominal +5 VDC). The output shall be adjustable from zero up to a point that a signal level 20 dB above RMS receiver noise can be obtained with 55 dB attenuation inserted between the generator and the receiver preamp. Any residual CW shall be at least 70 dB down. The output pulse width shall be 0.6 ± 0.1 microsecond. The RF pulse output and the noise test generator (3.11.7.3) output shall be combined prior to the attenuator (3.11.7.3) input.

3.11.6.5 Circuit interaction.- All IF and video modules shall be designed to preclude interaction between normal and MTI IF and video portions of the receiver, even with extreme maladjustment of any combination of IF, video and video limit level gain controls. The design of the IF pre-amplifier and amplifiers shall be such as to minimize feed-through.

3.11.6.6 Receiver system performance.- The individual receiver component performance characteristics previously specified are the minimum acceptable; the contractor shall provide any additional performance of any component as required to meet all other system performance specified herein. In addition, the receiver as a system shall perform as specified below:

Receiver Noise Figure*	4.0 dB Max.
Minimum discernible signal (MDS)	
Normal Receiver	-110 dBm
MTI Receiver	-108 dBm
Normal Log Receivers (as measured at output of anti-log circuit)	Not more than 1.0 dB below the normal linear receiver MDS.
MTI Log Receiver (as measured at output of anti-log circuit)	Not more than 2.0 dB below the MTI linear receiver MDS

*Referenced to receiver waveguide test coupler between circulator and diplexer.

All receiver performance requirements shall be met for reception on both the main (low beam) and passive (high beam) feed horns.

3.11.7 MTI and Normal logarithmic receiver circuitry.- The action of the logarithmic receiver circuitry shall provide a super clutter capability for aircraft targets that are competing with precipitation clutter returns. It shall be designed so that when it is selected for use, any aircraft target that has a signal return 2 dB greater than the precipitation clutter will not be precluded from detection due to saturation or limiting of the IF and video for clutter levels up to 58 dB above MDS noise level for the normal channel and to within 2 dB of the MTI IF limit level for the MTI channel. In addition, the logarithmic receiver circuitry shall reduce precipitation clutter signals to noise level.

3.11.7.1 Normal log-FTC-anti-log circuitry.- A logarithmic amplifier followed by a fast time constant (FTC) circuit and an anti-logarithmic amplifier shall be included in the receiver following the receiver preamplifier. The logarithmic receiver shall consist of a logarithmic IF amplifier (log IF) fed by the preamp followed by a fast time constant (FTC) circuit and an anti-logarithmic video circuit (anti-log). There shall be no leakage from any of the IF amplifiers to result in an FTC pedestal or other deleterious effects. No humps, video ringing, or baseline distortion shall be evident at the output of the anti-log circuitry. The minimum discernible signal of the normal logarithmic receiver shall be within 1 dB of the normal linear receiver.

The stability of the overall log IF, FTC, and anti-log circuitry shall be such that it shall not require adjustment more frequently than monthly in order to remain within the specified tolerances over the complete range of service conditions.

3.11.7.1.1 Logarithmic IF amplifier.- The bandwidth of the log IF shall be selected by the contractor to provide for optimum detection of aircraft returns when competing with precipitation clutter returns. The center frequency shall be between 29.8 and 30.2 MHz and the difference from the center frequencies of both the MTI and the normal linear IF shall not exceed 0.2 MHz. The center frequency shall be maintained within these limits and the bandwidth shall remain essentially constant over the complete dynamic range as specified below. If necessary, a bandpass filter shall be incorporated ahead of the log IF to maintain the constant bandwidth characteristic. The dynamic range of the log IF shall be at least 80 dB. A logarithmic characteristic within ± 1.0 dB of theoretical shall be maintained over the entire dynamic range at all frequencies between the 3 dB bandwidth; except that if a tighter tolerance is required to meet other specified requirements, the tighter tolerance shall be met. Provision shall be made so that the noise level at the input of the log IF can be adjusted so that the logarithmic characteristic can be operated at any desired level from 15 to 25 dB below the RMS noise level.

3.11.7.1.2 Fast time constant (FTC).- A fast time constant circuit design equal to or better in performance than the delay line/filter subtraction type shall be incorporated following the video output of the log IF and prior to the anti-log circuitry. The filter circuitry shall be designed to minimize any reduction in sensitivity following clutter blocks having fast fall time. The FTC circuitry shall automatically adjust the mean value of outputs from the log IF that are longer than the transmitter RF pulse width, so that the amplitude of the precipitation clutter and the noise are the same with respect to the baseline, while at the same time retaining the amplitude of point source target returns.

3.11.7.1.3 Anti-logarithmic video.- Following the FTC circuit, an anti-log video circuit shall be provided to restore the relative signal-to-noise level to that at the input to the log IF. The anti-log characteristic shall be maintained sufficiently above and below the noise level so that the appearance of the video when subsequently limited will resemble that produced by the normal linear IF and video amplifiers. A gain control shall be provided following the anti-log circuitry to permit the noise level to be adjusted to match any adjusted level of noise of the normal linear IF and video amplifiers. Provision shall be made for system control switching to select either the log-FTC-anti-log video or the normal video as the remoted video.

3.11.7.1.4 Weather video output.- A separate isolated video output of the normal log IF shall be provided. This output is to be used by the Government for weather outline contouring. A video gain control shall be provided so that the maximum video output of the weather channel can be adjusted from 2 volts peak to 5 volts peak. There shall be no limiting, saturation, The stability of the overall log IF, FTC, and anti-log circuitry shall be such that it shall not require adjustment more frequently than monthly in order to remain within the specified tolerances over the complete range of service conditions.

3.11.7.1.1 Logarithmic IF amplifier.- The bandwidth of the log IF shall be selected by the contractor to provide for optimum detection of aircraft returns when competing with precipitation clutter returns. The center frequency shall be between 29.8 and 30.2 MHz and the difference from the center frequencies of both the MTI and the normal linear IF shall not exceed 0.2 MHz. The center frequency shall be maintained within these limits and the bandwidth shall remain essentially constant over the complete dynamic range as specified below. If necessary, a bandpass filter shall be incorporated ahead of the log IF to maintain the constant bandwidth characteristic. The dynamic range of the log IF shall be at least 80 dB. A logarithmic characteristic within ±1.0 dB of theoretical shall be maintained over the entire dynamic range at all frequencies between the 3 dB bandwidth; except that if a tighter tolerance is required to meet other specified requirements, the tighter tolerance shall be met. Provision shall be made so that the noise level at the input of the log IF can be adjusted so that the logarithmic characteristic can be operated at any desired level from 15 to 25 dB below the RMS noise level.

3.11.7.1.2 Fast time constant (FTC).- A fast time constant circuit design equal to or better in performance than the delay line/filter subtraction type shall be incorporated following the video output of the log IF and prior to the anti-log circuitry. The filter circuitry shall be designed to minimize any reduction in sensitivity following clutter blocks having fast fall time. The FTC circuitry shall automatically adjust the mean value of outputs from the log IF that are longer than the transmitter RF pulse width, so that the amplitude of the precipitation clutter and the noise are the same with respect to the baseline, while at the same time retaining the amplitude of point source target returns.

3.11.7.1.3 Anti-logarithmic video.- Following the FTC circuit, an anti-log video circuit shall be provided to restore the relative signal-to-noise level to that at the input to the log IF. The anti-log characteristic shall be maintained sufficiently above and below the noise level so that the appearance of the video when subsequently limited will resemble that produced by the normal linear IF and video amplifiers. A gain control shall be provided following the anti-log circuitry to permit the noise level to be adjusted to match any adjusted level of noise of the normal linear IF and video amplifiers. Provision shall be made for system control switching to select either the log-FTC-anti-log video or the normal video as the remoted video.

3.11.7.1.4 Weather video output.- A separate isolated video output of the normal log IF shall be provided. This output is to be used by the Government for weather outline contouring. A video gain control shall be provided so that the maximum video output of the weather channel can be adjusted from 2 volts peak to 5 volts peak. There shall be no limiting, saturation, and preamp input and adjust the signal generator output for a video pulse amplitude of 4 times the RMS noise level at the anti-log video output. Record the video amplitude at each point as the signal generator output is reduced in 3 dB increments until the signal is reduced by a total of 12 dB. The signal amplitude at each point shall correspond to a theoretically linear characteristic within $\pm 20\%$. Any other test methods the contractor may wish to use shall be subject to Government approval.

3.11.7.2 MTI-log-FTC-circuitry.- The circuitry shall be totally digital in nature. Exception to this will be allowed only if it can be shown that the use of analog circuitry is required to meet the stated performance requirements. Provision for switching from MTI to log MTI shall be provided. The logarithmic circuitry shall consist of a digital logarithmic circuit (DLC) followed by a fast time constant (FTC) circuit and an anti-logarithmic circuit (anti-log), fed from an output from the MTI channel following cancellation, but prior to the limiting of the MTI video. The minimum discernible signal of the MTI logarithmic circuitry shall be within 2 dB of the regular MTI receiver. The stability of the overall DLC, FTC, and anti-log circuitry shall be such that it shall not require adjustment more frequently than monthly in order to remain within the specified tolerances over the complete range of service conditions.

3.11.7.2.1 Digital logarithmic circuit.- The dynamic range of the DLC shall be not less than that of the MTI A/D converter. It shall maintain a logarithmic characteristic within $\pm$ 0.5 dB of theoretical over the specified dynamic range except that if a tighter tolerance is required to meet other specified requirements, the tighter tolerance shall be met. Provision shall be made so that the DLC shall operate with an RMS noise level at the input at any desired level from 15 to 30 dB above the lower end of the specified logarithmic characteristic, as determined by the MTI IF gain control.

3.11.7.2.2 Fast time constant (FTC).- A digital fast time constant circuit equal to or better in performance than the delay/filter subtraction type, shall be incorporated following the output of the DLC prior to the anti-log circuitry. The circuitry shall be designed to minimize any reduction in sensitivity following clutter blocks having fast fall time. The FTC circuitry shall eliminate the mean value of outputs from the DLC that are longer than the transmitter RF pulse width, so that the amplitude of the precipitation clutter and the noise are equal, while at the same time retaining the amplitude of point source target returns.

3.11.7.2.3 Anti-logarithmic video data.- Following the digital FTC circuit a digital anti-log circuit shall be provided so as to restore the relative signal-to-noise level to that at the input to the DLC. The anti-log characteristic shall be maintained sufficiently above and below the noise level so that the appearance of the video when subsequently limited will resemble that produced by the regular MTI channel. A control shall be provided following the anti-log circuitry to permit the noise level to be adjusted to match any adjusted level of noise of the regular MTI channel. Provision shall be made for system control switching to select either MTI log-FTC-anti-log or MTI as the remoted video.

3.11.7.2.4 Weather background.- An output from the MTI just prior to being processed by the DLC, filtered to reduce the noise level, shall be used to provide weather background. A threshold level, adjustable between an input signal level of 10 dB above the RMS noise and maximum amplitude, which can be switched in or out, shall be provided. When the video data exceeds the threshold level, the weather background video data shall be blanked. This video data shall be fed to either one of two locally selectable circuits. One circuit shall top clip or limit the video data at a level adjustable between an input signal level of 0 and 15 dB above RMS noise, and bottom clip the video at an adjustable level between an input signal level of 0 and 15 dB above RMS noise. The other circuit shall bottom clip the video at an adjustable level between an input signal level of 0 and 15 dB above RMS noise and quantize the remaining video. The resulting background video from the selected circuits shall be fed through a variable amplitude circuit and then mixed with the log-FTC-anti-log video in an additive manner at any level from zero to a level which will allow the weather background and log-FTC-anti-log video levels to be matched. Provisions shall be made for local and remote step controls that will permit the background video to be adjusted to zero, maximum, and two intermediate levels. The maximum level shall be the level set by a local control.

3.11.7.2.5 Video coincidence.- Provision shall be included as necessary to insure that the video outputs are in time coincidence for the outputs of the MTI cideo, the MTI log-FTC-anti-log video, and the weather background video.

3.11.7.2.6 Overall logarithmic receiver performance.- The overall performance of the log, FTC, and anti-log circuitry shall be measured in accordance with the following test procedure: Using a pulse-modulated IF noise source (3.11.7.3) adjusted for 100 microseconds duration and a pulsed IF signal generator (3.11.6.4) adjusted to 0.6 microsecond duration, connect them through a calibrated variable attenuator and an IF coupler to the input of the MTI IF amplifier with the receiver mixer and preamp still connected. With 48 dB of attenuation inserted, adjust the output of the pulsed noise source to present a signal at the bi-polar output of the MTI receiver 10 dB above the RMS noise level. Adjust the non-coherent IF pulse signal to 12 dB above the RMS noise level. Superimpose the two pulses and observe the output of the anti-log video as the 48 dB attenuation is removed in 3 dB steps. At each step, the noise level of the noise pulse shall be essentially at the same level as the system noise, and video resulting from the IF pulse signal shall be detectable above the noise. This characteristic shall be maintained until limiting of the superimposed pulse combination begins to occur at the MTI IF limit, as observed at the bi-polar output of the MTI receiver. Disconnect the IF noise source and preamp input and adjust the signal generator output for a video pulse amplitude of 4 times the RMS noise level at the MTI anti-log video output. Record the amplitude at each point as the signal generator output is reduced in 3 dB increments until the signal is reduced by a total of 12 dB. The signal amplitude at each point shall correspond to a theoretically linear characteristic within ± 10%. Any other test method the contractor may wish to use shall be subject to Government approval.

3.11.7.3 Noise test generator.- A built-in IF noise source and variable attenuator shall be provided for each channel. The noise generator and the IF test pulse (3.11.6.4) shall be combined and the composite signal connected to the IF preamplifier through the attenuator to feed both the MTI and the normal logarithmic receiver circuitry. The noise generator shall have an adjustable output level up to 65 dB above the RMS noise level of the preamplifier. The variable attenuator shall have a minimum of 65 dB of attenuation removable in steps of 1 dB down to the insertion loss level. The insertion loss of the attenuator shall not be greater than 5 dB. The noise generator shall be capable of being gated on and off by an external source for any duration between 40 and 740 microseconds. The noise source output shall be gated on when a voltage greater than +3.5 VDC (nominal +5.0 VDC) is applied and gated off when a voltage less than 0.5 VDC (nominal 0.0 VDC) is applied. Provision shall be incorporated so that with a fast rise time gate input, the rise and fall time of the output noise shall be adjustable from 0.1 microsecond to 20 microseconds. The rise and fall time shall be essentially linear. A maintenance switch shall be provided so that the noise source can be turned on and off.

3.11.8 Radio frequency generator (RFG).- The RF frequency generator shall provide the receiver stable local oscillator signals, transmitter RF drive signal, coherent oscillator signals and other low level RF signals as required. The RFG shall derive all signals from not more than two crystal oscillators utilizing appropriate mixers and multiplier chains. Changing the operating frequency of the system shall require replacement of only one crystal per channel.

3.11.8.1 Shielding.- Radiation from the RFG shall not adversely affect radar system performance. The shielding shall be sufficient to prevent any fields from extraneous energy from interfering with the achievement of equipment performance requirements or resulting in any deterioration in system performance. Interconnecting cables and leads shall be shielded and filtered as required to prevent any frequency instability which may result from circuit cross-coupling or the transmission of transients from external circuits to the RFG.

3.11.8.2 Adjustment.- The RFG tuning procedure shall not be complicated or critical in adjustment. No tuning, operating adjustment, or test measurements shall be required more frequently than weekly. A frequency change of ±2 MHz shall be possible without retuning.

3.11.7.3 Noise test generator.- A built-in IF noise source and variable attenuator shall be provided for each channel. The noise generator and the IF test pulse (3.11.6.4) shall be combined and the composite signal connected to the IF preamplifier through the attenuator to feed both the MTI and the normal logarithmic receiver circuitry. The noise generator shall have an adjustable output level up to 65 dB above the RMS noise level of the preamplifier. The variable attenuator shall have a minimum of 65 dB of attenuation removable in steps of 1 dB down to the insertion loss level. The insertion loss of the attenuator shall not be greater than 5 dB. The noise generator shall be capable of being gated on and off by an external source for any duration between 40 and 740 microseconds. The noise source output shall be gated on when a voltage greater than +3.5 VDC (nominal +5.0 VDC) is applied and gated off when a voltage less than 0.5 VDC (nominal 0.0 VDC) is applied. Provision shall be incorporated so that with a fast rise time gate input, the rise and fall time of the output noise shall be adjustable from 0.1 microsecond to 20 microseconds. The rise and fall time shall be essentially linear. A maintenance switch shall be provided so that the noise source can be turned on and off.

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3.11.8.2 Adjustment.- The RFG tuning procedure shall not be complicated or critical in adjustment. No tuning, operating adjustment, or test measurements shall be required more frequently than weekly. A frequency change of ±2 MHz shall be possible without retuning.

3.11.8.6 Metering.- A built-in tuning meter with appropriate switching shall be provided for tuning the RFG.

3.12 RF plumbing.- Waveguide shall be used throughout the high-power RF path and in both receive paths from the polarizers to the input to the antenna pattern selector. The entire transmitter RF system shall withstand without damage a test to be performed by the contractor of 1.5 megawatts at 0.002 duty cycle with a VSWR of at least 1.5:1 at normal atmospheric pressure and shall have a normal power handling capacity of at least 1.25 megawatt peak at 0.002 duty cycle. The total insertion loss of all components in the transmitter signal path from the RF output tube connector through the high power diplexer (3.13.1) shall not exceed 1.4 dB. All components shall have an outside protective coating to increase their resistance to corrosion. Standard WR-284 waveguide shall be used throughout the system. The entire RF system, including the antenna, shall be capable of being pressurized to 5 PSIG. Integrity of the seals shall prevent a rate of pressure decrease in excess of 0.5 PSI in 24 hours, starting from a pressure of 3 PSIG.

3.12.1 Waveguide circulator.- The duplexer in each transmitter shall employ a high-power four port ferrite waveguide circulator. The circulator shall isolate the output tube to the extent required to insure optimum spectrum and power output. Performance of the circulator shall be essentially constant over the frequency range of 2.7 to 2.9 GHz. Port connections shall be as follows: Port 1-transmitter, port 2-antenna, port 3-receiver, and port 4-dummy load. The VSWR, as measured in the forward direction between any two adjacent ports, shall not excced 1.15:1 over the frequency range of 2.7 to 2.9 GHz. The isolation between ports 2 and 1 shall be at least 22 dB over the frequency range of 2.7 to 2.9 GHz. The isolation between ports 1 and 3 shall be at least 20 dB over the frequency range of 2.7 to 2.9 GHz. The isolation, as measured in the reverse direction between any two adjacent ports not previously specified, shall be at least 18 dB over the frequency range of 2.7 to 2.9 GHz. The isolation, VSWR, and insertion loss requirements shall be met under circuit impedance conditions equal to the operating conditions actually encountered in the radar system. The circulator shall have no movable or adjustable parts and shall not require forced air or water cooling. The circulator shall be equipped with an external dummy load which is properly matched to the circulator. The dummy load shall be capable of dissipating the full specified transmitter power output without damage for a time duration of 30 seconds.

3.12.2 Flexible waveguide.- A flexible section of waveguide shall be provided between the output tube and the waveguide system to prevent mechanical strain on the output tube connector.

3.12.3 Directional couplers.- Permanently installed waveguide directional couplers shall be provided as necessary to make the following measurements at the points indicated:

(a) Forward and reverse power on antenna side of high power diplexer.

(b) Forward and reverse power between high power diplexer and circulator in each channel.

(c) Main (low beam) receiver sensitivity and noise figure with coupler(s) installed between high power diplexer and circulator. Provisions shall be included for injection of a signal from an S band signal generator and a noise source.

(d) Same capability as in (c) above for passive (high beam) receive path. The coupler(s) shall be installed on the antenna side of the TR device.

The degree of coupling in all cases listed above shall be appropriate to the intended purpose. Calibration charts indicating the degree of coupling for the 2700 to 2900 MHz frequency band shall be permanently recorded on or adjacent to all couplers. All directional couplers, except those used for measurement of reverse power, shall have a minimum directivity of 20 dB. Minimum directivity of reverse power couplers shall be 27 dB. The VSWR shall not exceed 1.1:1; insertion loss shall not exceed 0.2 dB for any coupler over the entire 2700 to 2900 MHz band. Couplers shall be furnished with Type N coaxial jacks.

3.12.4 Lowpass filter.- A lowpass filter of the absorption type shall be provided for each channel to attenuate radiated harmonic frequencies. The insertion loss from 2700 MHz to 2900 MHz shall not exceed 0.15 dB and the VSWR from 2700 MHz to 2900 MHz shall not exceed 1.1:1. The attenuation at the 2nd, 3rd and 4th harmonic shall not be less than 40 dB, 30 dB and 10 dB, respectively. The average power handling capability shall not be less than 4 KW. The peak power handling capability shall not be less than 1.5 MW. If pressurization of the filter is required, a permanently installed pressure gauge and a means for replenishing the gas supply shall be provided. The filter shall not require cooling other than convection and radiation. The filter shall affect only the transmit path.

3.12.5 Waveguide switch.- Waveguide switches shall be provided for each channel to switch the channel between the antenna and the RF dummy load. The waveguide switches and drive shall be of rugged construction, strong, and reliable. Vane-type switching is prohibited. Electrical and mechanical overload protection shall be provided for the waveguide switches. Interlocks shall be incorporated to permit application of high voltage only when the dummy load or the antenna is connected to the output of the transmitter with the waveguide switch accurately aligned in each of two positions. Positive positioning of the waveguide switch shall be incorporated. The heat dissipated in the RF dummy loads shall not cause mechanical binding of the switches. The waveguide switches shall not require lubrication or routine maintenance more frequently than yearly. The voltage standing wave ratio (VSWR) of the waveguide switch shall not exceed 1.1:1 over the entire frequency range from 2.7 to 2.9 GHz in either operating position. The cross-coupling attenuation (electrical isolation) of the waveguide switch shall be at least 70 dB between the two operating positions, and the attenuation (insertion loss) of the waveguide switch shall not exceed 0.1 dB in either operating position over the entire frequency range from 2.7 to 2.9 GHz. The waveguide swtich shall be installed on the antenna side of the circulator in each channel so that when the channel is taken off-line, both the transmitter and the low beam receive path are isolated from the antenna.

3.12.6 Transmitter RF dummy load.- An RF dummy load capable of continuously dissipating 1.5 megawatts peak, 4500 watts average RF power without damage or deterioration shall be provided for each channel. Each RF dummy load shall present a load impedance such that the voltage standing wave ratio shall be constant and not exceed 1.1:1 over the entire frequency range of 2.7 to 2.9 GHz. Water or forced air cooling for the dummy load is prohibited. Precautions shall be taken for the prevention of hot spots in the loads and RF leakage shall be held to a minimum.

3.12.7 Waveguide.- All waveguide between the antenna assembly and the equipment in the transmitter/receiver building shall be provided. Tower heights will range between 17 and 77 feet. All supports for waveguide inside the building and on the tower shall be provided. An entrance sealing device shall be provided to seal the building against all weather conditions where waveguide and beacon coaxial cable pass through the wall. Fittings and seals shall be provided to pressurize the entire waveguide run. If parts such as the high power diplexer require individual pressurization, provisions shall be made to bypass these parts so as to maintain the overall system pressure.

3.13 Dual frequency diversity.- The equipment shall be capable of operating both channels into the antenna simultaneously in a dual diversity mode in addition to the usual single channel mode of operation. To accomplish this, a high power diplexer shall be provided to simultaneously connect the radar transmitter/receiver of both channels to the main (low beam) antenna circuit; a low power diplexer shall likewise be provided to simultaneously connect the receiver of both channels via the antenna pattern selector to the passive (high beam) antenna circuit. Provisions shall be made to additively combine video reply signals from both channels; to properly synchronize the two channels; to permit switching of either channel between the antenna and a dummy load, etc., as specified in subparagraphs hereunder. Waveguide and other switching and control shall be provided as necessary to operate in either a dual diversity or single channel mode. When single channel is selected, the standby channel shall be terminated into a dummy load.

3.13.1 High power diplexer.- The high power diplexer shall permit simultaneous operation of both transmitter/receivers with a frequency separation between channels of 60 MHz or more and a time separation between the pulses transmitted by each channel of not more than 1.5 microseconds (3.13.3). Operating characteristics of the diplexer shall be as specified below:

Tuning	Fixed tuned
Frequency	2700 to 2900 MHz
Input frequency separation	60 MHz minimum
Channel isolation	60 dB minimum
Insertion loss (receive or transmit)	0.5 dB maximum
VSWR (receive or transmit)	1.2:1 maximum
Power capacity	1.5 MW peak, 1.5 KW average (into each port)

If pressurization of the diplexer is required, a permanently installed pressure gauge for monitoring and a means of replenishing the gas supply shall be furnished. The diplexer shall be provided with waveguide flanges which are directly compatible with the system waveguide.

3.13.2 Low power diplexer.- The electrical characteristics of the low power diplexer shall be at least equal to those of the high power diplexer, except that the power capacity need only be as required to operate at the levels encountered in the passive, receive only path.

3.13.3 Synchronization.- To reduce the peak power capacity required of RF system components common to both radar transmitters, operation of the two transmitters shall be synchronized but time offset, so that one fires ahead of the other. It shall be possible to select either of the two channels as the master channel; the other channel is then the slave. The master channel provides all necessary timing for the slave channel; the slave channel timing is delayed as necessary so that its transmitter pulses lag those of the master channel by 1.5 ± 0.1 microsecond. Pre-triggers provided for synchronization of the radar beacon, displays or other external equipment shall maintain the same time relationships with respect to radar zero range regardless of whether the radar is operating in dual diversity or a single channel mode.

3.13.4 Video combiner.- Each channel shall include circuitry to separately combine the MTI and normal video signals from the two channels. The combiners associated with the radar channel selected as master shall automatically provide the output video. The combiners shall realign and additively combine the video reply signals from the two channels. Video limiting shall not be accomplished until after the channelized signals are combined. The combiner shall include provisions to automatically maintain a constant noise output and signal limit level whether the system is operating in a diversity or single channel mode; likewise, the pre-trigger to radar zero range timing shall remain constant regardless of the mode of operation. There shall be no discernible difference in output video rise time, duration, fall time, or jitter with respect to pre-trigger when operation is in diversity as opposed to single channel mode.

The output from the combiners shall be limited MTI and Normal video, with the limit levels adjustable over a range suitable to give at least a 6:1 signal to noise ratio with normal receiver gain settings.

3.13.5 Dual diversity control.- Selection of either dual diversity or single channel operation shall be possible from the system control panels. When in dual diversity, the receiver gain and STC settings of the slave channel shall automatically correspond to the settings of the master channel, and shall follow any changes made to the settings of the master channel.

3.14 Processor assembly.- The processor cabinet shall include the MTI cancellers, video enhancer, synchronizer, MTI log circuitry, power supplies, etc., mounted in a cabinet of the type specified in 3.18.1. The processor assembly shall perform and be designed in accordance with the requirements of subparagraphs hereunder and other applicable specification requirements.

3.14.1 Synchronizer.- The basic timing for the T/R equipment, as well as timing for the radar beacon, displays and other external equipment shall be derived from a single crystal controlled clock. The stability of this clock shall be as required to result in system performance in accordance with all specified requirements. It shall be possible to decrease the nominal clock frequency at least 5% in 1% increments merely by changing the crystal.

3.14.1.1 PRF staggering.- The synchronizer shall provide all timing as required to operate the system in a multi-stagger (4 or more) mode or an unstaggered mode, either mode to be selected by means of a front panel switch. The number of stagger periods and the stagger ratios shall result in the specified MTI system performance (3.14.2.1). The following constraints apply in selection of stagger periods:

1. Average staggered PRF shall be not less than 1030 PPS (at nominal clock frequency).

2. No period shall be less than 830 microseconds.

3. The counted down beacon pretrigger shall fall within the range of 340 to 450 PPS.

In addition, the stagger periods and stagger sequence should be selected so as to have the least adverse affect on the transmitter/modulator and to facilitate video realignment (3.14.2). The contractor shall submit his recommended stagger scheme, together with data to indicate that all requirements are met, for review and approval of the contracting officer. Submission shall be made not later than 90 days after award of contract; the Government will respond within 15 working days following receipt.

3.14.1.2 Trigger requirements.- The synchronizer shall provide all internal timing and triggers as required by the equipment design; in addition, the

The output from the combiners shall be limited MTI and Normal video, with the limit levels adjustable over a range suitable to give at least a 6:1 signal to noise ratio with normal receiver gain settings.

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3.14 Processor assembly.- The processor cabinet shall include the MTI cancellers, video enhancer, synchronizer, MTI log circuitry, power supplies, etc., mounted in a cabinet of the type specified in 3.18.1. The processor assembly shall perform and be designed in accordance with the requirements of subparagraphs hereunder and other applicable specification requirements.

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3.14.1.2 Trigger requirements.- The synchronizer shall provide all internal timing and triggers as required by the equipment design; in addition, the

3.14.1.2.5 Counted down beacon pretrigger.- The aligned pretriggers specified in 3.14.1.2.4 shall be counted down as necessary to be within the range of 340 to 450 PPS. This trigger shall be available for use in synchronizing the beacon interrogator to the radar.

3.14.1.3 Master/slave synchronization.- In both the single channel and dual diversity modes of operation, synchronization of the system shall be in a master/slave manner. In the single channel mode, the synchronizer of the operating (master) channel shall provide all synchronization for both radar channels and for the associated external equipment (radar beacon, displays, etc.). A maintenance control shall be provided to permit synchronization of the standby (slave) channel from its own synchronizer; this control shall be interlocked, however, so that it is disabled when the standby channel transmitter is radiating. In the dual diversity mode, synchronization shall be as specified in 3.13.3, with the channel whose transmitter is first energized becoming the master channel. A maintenance control shall be provided to allow selection of either channel as the master channel once both channels are on the antenna and transmitter voltage applied.

3.14.2 Moving target indicator (MTI).- A moving target indicator (MTI) system shall be provided with each channel. The MTI system shall be of the coherent type, employing a coherent frequency reference, limiting type receiver, and digital cancellers. Velocity response of the MTI system is enhanced through operation on a staggered PRF; however, realignment of all videos shall be accomplished so that the beacon, displays, mappers, etc., can operate at an unstaggered PRF. Realignment must have a dynamic range of at least 30 dB, utilizing 5 bits, if performed just prior to the video output, and 9 bits minimum if performed prior to cancellation.

3.14.2.1 System MTI performance.- The complete T/R system shall be designed and fabricated in such a manner as to produce MTI performance as specified below:

MTI improvement factor	*NLT 34 dB
System subclutter visibility (SCV)	NLT 28 dB

*NLT - Not less than

The staggered operation shall result in a first MTI blind speed of not less than 800 knots, with no dips or nulls in the velocity response in excess of 10 dB measured peak-to-peak at any velocity less than the first blind speed.

3.14.2.2 MTI canceller characteristics.- The cancellation system shall be comprised of a double canceller with feedback. Each canceller shall provide sufficient storage for 60 miles of MTI. The range bin width of the canceller shall not exceed 80% of the system pulse width. The bipolar video from the phase detector shall be quantized into not less than one sign bit and eight amplitude bits. Timing jitter between the transmitted RF pulse and the reference trigger used by the cancellers shall not exceed 5 nanoseconds.

3.14.2.3 Video cancellation ratio.- The video cancellation ratio of each of the single cancellation systems of the cascade double and shaped cancellation system shall be not less than 40 dB (using optimum speed moving targets of the test pulse generator specified in 3.14.2.12). The total overall video cancellation ratio of the cascade double and shaped cancellation system shall be not less than the maximum dynamic range of the equipment in dB. The video subclutter visibility of each of the single cancellation systems of the cascade double and shaped cancellation system shall not be less than 35 dB (with superimposed optimum speed moving targets double the fixed target residue amplitude).

3.14.2.4 Operational modes.- The MTI system shall provide for selection of the following modes of operation:

(a) Operation utilizing either one of the two cancellers.

(b) Operation utilizing both cancellers in cascade without feedback.

(c) Operation utilizing both cancellers in cascade with feedbacks providing four different degrees of velocity response shaping.

3.14.2.5 Selector switch.- The selection of different modes of operation shall be made by means of a maintenance selector switch without requiring readjustments to the system in each position of operation.

3.14.2.6 Feedback loops.- There shall be a minimum of 2 feedback loops in the cascade cancellation system for accomplishing velocity response shaping. The gain of the feedback loops shall remain constant over the service conditions to prevent oscillation.

3.14.2.7 SCV limitation selector switch.- Four different velocity shapes shall be made available by means of a maintenance selector switch. Velocity-shaped cancellation shall be incorporated so that the limitation on subclutter visibility due to scanning clutter alone will be greater than 25, 30, 35, and 40 dB for antenna rotation of 12.5 rpm, provided the proper velocity shape is selected.

3.14.2.8 Adjustment.- The cancellation systems shall not require adjustment more frequently than weekly.

3.14.2.9 Output signal characteristics.- The output of the MTI channel shall be linear MTI video, adjustable to provide at least a 6:1 signal-to-noise ratio with normal receiver gain settings. At least two isolated 75 ohm MTI video outputs shall be provided.

3.14.2.10 Output signal fidelity.- All units shall be well shielded and filtered to prevent ripple, interference, or modulation from entering the critical circuitry of the MTI equipment. No humps, video ringing, or base line modulations shall be present on MTI video output even with advancement of gain controls beyond normal levels. With the antenna stopped, there shall be no jumping of uncancelled residue. MTI residue and MTI video limit level shall not change with the advancement of MTI IF gain control beyond normal operating position. Coherent bi-polar video shall not unbalance with MTI IF gain control adjustments. No IF amplifier saturating characteristics shall exist to produce dead areas following strong clutter returns. No parasitic oscillations or instabilities shall exist in the equipment with any position of the gain and maintenance alignment controls.

3.14.2.11 Built-in test equipment (BITE).- Digital BITE shall be provided to check the logic and storage function of the digital MTI, including the means for checking the velocity response.

3.14.2.12 Video test pulse generator.- A built-in video test pulse generator shall be included for instantaneous video-cancellation measurements during the dead time period. Negative and positive fixed targets and optimum speed moving targets shall be simulated by the test generator.

3.14.3 Video enhancer.- A digital video signal enhancer shall be incorporated in each normal channel and MTI channel of the dual channel radar system. Local and remote selector switches shall be provided with each enhancer in order that normal or MTI may be obtained with or without enhancement. The video enhancer shall provide desired signal enhancement and interference reduction. Video enhancement of 20 dB minimum shall be provided. Adjustment shall be provided to maintain the same noise level when the enhancer is turned on and off. There shall be no evidence of the circuitry going into oscillation due to large blocks of clutter return.

3.14.3.1 Feedback.- The memory for each range cell shall contain the sum of the most recent echo signal and a fraction of the prior value for the same echo. The feedback factor shall be between the limits 0.85 and 0.95. The exact feedback factor shall be selected to provide optimum performance with the average number of hits available per beamwidth of the antenna while rotating at 12.5 rpm.

3.14.3.2 Input limiter.- The input signal shall be limited approximately 6-10 dB above RMS noise level in order to prevent a single strong interference pulse from producing a detectable output from the integrator. To minimize the degradation of detectability of desired targets, the input dynamic range shall be as large as possible, consistent with the rejection of single pulse interference.

3.14.3.3 Output limiter.- The buildup of signal in the integrator memory shall be limited in order to minimize the azimuth smear caused by strong targets and the exponential decay characteristics of the integrator. The dynamic range at the output shall provide optimum contrast for a PPI display.

3.14.3.4 Bottom clipper.- The video from the integrator shall be compatible with amplifiers which utilize DC restorers. In order to provide a predictable baseline, the integrator shall include a bottom clipper. A number shall be subtracted from the value in the integrator memory which, in the presence of system noise, will produce a negative result approximately 10% of the time; all negative results shall be converted to zero.

3.14.4 Range/azimuth gate generator (RAG).- A separate device shall be furnished with each channel to generate programmable azimuth/range windows, azimuth gates, or range gates and perform other functions as outlined below:

a. Gating of either of two video signals to one output line during any one of the programmable range/azimuth windows.

b. Outputs for antenna beam switching.

c. Outputs for control of the noise signal generator.

d. Azimuth strobe outputs.

e. Delayed, gated trigger.

f. Azimuth gating of stagger/non-stagger operation.

3.14.4.1 Range/azimuth gate generator synchronization.- Range-dependent functions of the RAG shall be synchronous with the firing of the channel transmitter. The range counter shall be capable of being reset to a negative range equivalent to the time between pretrigger and the time of occurrence of an output target at zero range. The least significant bit of the range counter shall be 1/16 nautical mile or less; the maximum count shall be at least equivalent to the range from pretrigger time to 60 nautical miles after zero range. Azimuth-dependent functions of the RAG shall be synchronous with the APG data received from the antenna. The azimuth counter shall be a 12 bit counter capable of being reset to any count from zero to 4095 upon sensing of an ARP from the antenna. The least significant bit shall be 1 ACP. Frequency and stability of the range counter shall be as required to insure system performance in accordance with all specified requirements; for example, there shall be no evidence of switching transients, uncancellation, or other adverse effects in the output videos as a result of switching from high to low beam as controlled by the RAG. The azimuth counter output shall be sampled only during radar dead time (time from 60 nautical miles to the next pretrigger).

3.14.4.2 Video gating.- The RAG shall provide for selection of one of two video signals on a range/azimuth basis. One video shall be selected from zero range out to the desired switch point, where the other video shall be selected on out to 60 nautical miles. The RAG shall have the capability of generating not less than 20 such range/azimuth windows beginning at zero range and adjoining in azimuth. In addition, the capability shall be provided to generate not less than 10 isolated windows. An extra isolated 75 ohm (nominal) output shall be provided at an amplitude of at least +5 VDC. The gating unit shall normally select between MTI and normal video; however, it shall be possible to cable patch other videos into the gating unit. A maintenance switch shall be provided to select either the gated video or MTI video for remoting.

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<u>3.15 System control and interface</u>.- A single cabinet of the type specified in 3.18.1 shall be provided to house all T/R subsystem control and interface circuitry. This includes, but is not limited to, system control circuitry and associated DC power supplies, channel selection circuitry, video and trigger line drivers, azimuth data line drivers and video isolation amplifiers. A wall mounted Radar Cable Junction Box (RCJB) shall be provided as a single common junction point between the control and interface cabinet and the remoting equipment (land lines or microwave link). An identical junction box shall be provided for installation at the remote site as an interface point between the remoting equipment and the remote site units of the T/R subsystem, as well as associated equipments (beacon processor, for example).

<u>3.15.1 System control</u>.- In addition to complete local control, provision shall be made for partial control of the system from one or more points at the remote site. Status indicators (readback functions) shall be provided to enable operators at the remote site to monitor the condition of the system. All remoted controls and readbacks shall be binary in nature, and shall operate satisfactorily over any length of #22 AWG multi-conductor cable up to a maximum of 20,000 feet. Detailed control system requirements are specified in subparagraphs hereunder.

<u>3.15.1.1 Point of control</u>.- It shall be possible to designate either of two control panels at the remote site or a similar panel at the T/R site as the point of system control. Four identical control panels (boxes) shall be provided; two for installation at the remote site; one for local control of the system and the fourth to be used as an installed spare at the local site. Each control panel shall include momentary switches for taking or relinquishing control of the system. The transfer of control from any one of the three active control boxes to another shall require the deliberate and simultaneous action of two parties; one depressing the "Release Control" pushbutton on the box in control; the other depressing the "Take Control" pushbutton on the box to which control is to be transferred. An audible signal shall sound at all three active control boxes during the time that the "Release Control" button is depressed. The system status shall remain unchanged during and subsequent to a control point transfer until some change is made at the new control point. Indicator lights on each control panel shall indicate whether that panel has or does not have control of the system.

<u>3.15.1.2 On-line control</u>.- Both channels may be placed on line, operating in a dual diversity mode. In this mode, system control (except for primary power control) resides entirely in the control panel designated as the point of control. Synchronization for both channels shall be provided by the master channel; likewise, the receiver gain of the master channel shall determine the gain of the slave. Either channel may be designated as the master channel, with the other being slaved to it. The master channel shall be the one to which high voltage is first applied; loss of high voltage on the master channel shall cause the master/slave designation to change channels.

3.15.1.3 Off-line control.- Single-channel operation, with the inactive channel terminated into a dummy load, shall be possible for maintenance of the system. Placing a channel in off-line status shall automatically remove transmitter high voltage and switch the channel to dummy load. It shall be possible to restore high voltage to the off-line channel from the designated control point unless it is in maintenance status as described below. A "Maintenance" switch shall be provided at the local site for each channel. The function of this switch is to transfer complete control of the off-line channel to the local site. The maintenance control shall prevent selection of the off-line channel from the remote site; conversely, operation of the maintenance switch shall have no affect on a channel unless it has first been taken off-line. A channel in maintenance status shall be controlled by controls located on the individual equipment cabinets.

3.15.1.4 Control signal characteristics.- The radar system control circuit design shall employ ground signals or open circuit signals as specified herein to accomplish all system control and readback functions. Each control and readback function shall have a spare isolated single pole double throw (SPDT) switching capability associated therewith and the three switch points shall be terminated on the cabinet terminal strips.

3.15.1.5 Control functions.- A control function shall be initiated by applying a momentary ground signal to the appropriate control connection. A momentary ground is defined as a signal having a duration equal to or greater than 0.01 second. The maximum current that shall be allowed to flow during the ground signal shall be 100 milliamperes. The maximum open circuit voltage that can appear on any control function connection point shall be limited to 24 volts and it shall be a positive DC voltage. A control function shall control a readback function only on an indirect basis as a result of an executed control function.

3.15.1.6 Readback function.- A readback function shall automatically be initiated as a result of a control being initiated and executed or by some other specified automatic function such as a system alarm, interlock, etc. A readback function is a ground signal applied to the appropriate readback function connection and its duration shall be controlled by the duration of and the status of the function being monitored. The readback function signal switching circuit shall be rated to handle 1 ampere at 24 volts DC. The maximum open circuit voltage that can appear on any readback control function connection point shall be limited to 24 volts and it shall be a positive DC voltage. Extra contacts specified in 3.15.1.4 shall be connected to the radar cable junction box and shall be used for readback between the remote and local site. Any and all energized readback functions shall appear on all three active control panels.

3.15.1.7 Common system controls.- Common system controls shall be provided for the following functions. Control initiation and readback status display shall be combined into control switches similar and equal in function and appearance to Micro Switch Series 2C200. Separate readback status displays

3.15.1.3 Off-line control.- Single-channel operation, with the inactive channel terminated into a dummy load, shall be possible for maintenance of the system. Placing a channel in off-line status shall automatically remove transmitter high voltage and switch the channel to dummy load. It shall be possible to restore high voltage to the off-line channel from the designated control point unless it is in maintenance status as described below. A "Maintenance" switch shall be provided at the local site for each channel. The function of this switch is to transfer complete control of the off-line channel to the local site. The maintenance control shall prevent selection of the off-line channel from the remote site; conversely, operation of the maintenance switch shall have no affect on a channel unless it has first been taken off-line. A channel in maintenance status shall be controlled by controls located on the individual equipment cabinets.

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3.15.1.7 Common system controls.- Common system controls shall be provided for the following functions. Control initiation and readback status display shall be combined into control switches similar and equal in function and appearance to Micro Switch Series 2C200. Separate readback status displays readback status display lamp shall not exceed 50 milliamperes.

Function	Control	Readback
1. Receiver Sensitivity MAX	X	X
2. Receiver Sensitivity -1	X	X
3. Receiver Sensitivity -2	X	X
4. Receiver Sensitivity -3	X	X
5. Receiver Sensitivity -4	X	X
6. Receiver Sensitivity -5	X	X
7. Receiver STC OFF	X	X
8. Receiver STC #1	X	X
9. Receiver STC #2	X	X
10. Receiver STC #3	X	X
11. Normal Video ON	X	X
12. Log Video ON	X	X
13. Normal/Log Enhancer ON	X	X
14. Normal/Log Enhancer OFF	X	-
15. MTI Video ON	X	X
16. MTI Log Video ON	X	X
17. MTI Enhancer ON	X	X
18. MTI Enhancer OFF	X	-
19. Weather Background MTI OFF	X	X
20. Weather Background MTI 1	X	X
21. Weather Background MTI 2	X	X
22. Weather Background MTI 3	X	X
23. Weather Background Normal OFF	X	X
24. Weather Background Normal 1	X	X

	Function	Control	Readback
25.	Weather Background Normal 2	X	X
26.	Weather Background Normal 3	X	X
27.	Spare	X	X
28.	Spare	X	X

3.15.1.9 System control panels.- Four identical system control panels shall be provided. Two of the panels are for installation at the remote site; of the remaining two panels, one shall be installed in the control and interface assembly (3.15) for local control of the system, with the fourth panel installed as a spare in the control and interface assembly adjacent to the active panel. The panels shall be designed for flush mounting and shall include a dust cover to protect all wiring, etc. The dimensions of each panelshall not exceed 12 inches in width, 16 inches in height and 6 inches in depth. All external connections to the panels shall be by means of quick-disconnect jacks and plugs. Each panel shall be complete with a single phase DC power supply to power background and readback status lights. Each power supply shall be individually controlled and shall provide positive DC voltages not to exceed 24V. Provision shall be made for adjusting the power supply output voltage or to otherwise control the voltage across the indicator lamps on the control box from their full rated voltage down to approximately one-third the rated voltage. Regulation and ripple shall be as required to insure normal system operation over the range of service conditions.

3.15.1.10 Control power supplies.- Two independent modular DC power supplies shall be provided for operation of all system control circuitry other than readback lamps on the control boxes. The control voltage shall be positive, and not in excess of 24 volts. The two power supplies shall be simultaneously connected to the control circuitry supply bus through disconnect diodes. The output voltage of each power supply shall be sensed, with failure being indicated by a status light. Except for regulation and ripple, the control voltage power supplies shall be in accordance with all requirements of 3.17.1.8 and subparagraphs, as well as all other applicable specification requirements. Regulation and ripple shall be as required to insure normal system operation over the range of the service conditions. Each power supply shall be of sufficient capacity to handle the full system load over the range of service conditions.

3.15.1.11 Alarm controls.- Alarm controls shall be provided in each radar channel to report, as a minimum, the alarms specified below. Where the design includes other functions that logically should be reported, these additional alarms shall be included.

1. Transmitter Overvoltage
2. Transmitter Undervoltage
3. Transmitter Overcurrent

	Function	Control	Readback
25.	Weather Background Normal 2	X	X
26.	Weather Background Normal 3	X	X
27.	Spare	X	X
28.	Spare	X	X

3.15.1.9 System control panels.- Four identical system control panels shall be provided. Two of the panels are for installation at the remote site; of the remaining two panels, one shall be installed in the control and interface assembly (3.15) for local control of the system, with the fourth panel installed as a spare in the control and interface assembly adjacent to the active panel. The panels shall be designed for flush mounting and shall include a dust cover to protect all wiring, etc. The dimensions of each panelshall not exceed 12 inches in width, 16 inches in height and 6 inches in depth. All external connections to the panels shall be by means of quick-disconnect jacks and plugs. Each panel shall be complete with a single phase DC power supply to power background and readback status lights. Each power supply shall be individually controlled and shall provide positive DC voltages not to exceed 24V. Provision shall be made for adjusting the power supply output voltage or to otherwise control the voltage across the indicator lamps on the control box from their full rated voltage down to approximately one-third the rated voltage. Regulation and ripple shall be as required to insure normal system operation over the range of service conditions.

3.15.1.10 Control power supplies.- Two independent modular DC power supplies shall be provided for operation of all system control circuitry other than readback lamps on the control boxes. The control voltage shall be positive, and not in excess of 24 volts. The two power supplies shall be simultaneously connected to the control circuitry supply bus through disconnect diodes. The output voltage of each power supply shall be sensed, with failure being indicated by a status light. Except for regulation and ripple, the control voltage power supplies shall be in accordance with all requirements of 3.17.1.8 and subparagraphs, as well as all other applicable specification requirements. Regulation and ripple shall be as required to insure normal system operation over the range of the service conditions. Each power supply shall be of sufficient capacity to handle the full system load over the range of service conditions.

3.15.1.11 Alarm controls.- Alarm controls shall be provided in each radar channel to report, as a minimum, the alarms specified below. Where the design includes other functions that logically should be reported, these additional alarms shall be included.

1. Transmitter Overvoltage

2. Transmitter Undervoltage

3. Transmitter Overcurrent

connect the beacon output video to the remoting system. All coaxial jacks shall be installed on a panel which can be either grounded or ungrounded as the requirements of associated equipments may dictate. A barrier terminal strip (one each 20 terminal) shall be provided to accommodate beacon control wiring; terminal strips, as required, shall also be provided for the intercommunications system wiring.

<u>3.15.2.2 Radar output signals</u>.- For land line remoting, normal video and radar pre-trigger shall be combined so as to permit remoting over a single coaxial cable. MTI video shall be remoted on a second line. Dual channel line drivers (3.15.2.3.1) shall be provided to interface the radar with the coaxial remoting lines. For microwave link remoting, the radar shall provide separate isolated outputs of normal video, MTI video and radar pretrigger. For synchronization of the radar beacon, the radar shall provide a counted-down radar pretrigger (3.14.1.2.5) and an aligned zero range trigger (3.14.1.2.3). All of the above signals shall be routed to the RCJB via the Control and Interface Assembly. In the case of single channel operation, the Control and Interface Assembly shall select the signals from the active channel as output signals; in the case of dual diversity operation, the output signals shall come from the master channel. In addition to the output signals routed to the RCJB, the Control and Interface Assembly shall include isolated output jacks as required to fully monitor system operation by use of the maintenance PPI. Signals from both of the dual antenna azimuth position data systems (3.8.9.1) shall be remoted, with the capability to select either system provided at the remote site. Isolated outputs of antenna azimuth position data shall be provided at the control and interface assembly and at each channel processor assembly for use by the maintenance PPI.

<u>3.15.2.2.1 Output signal characteristics</u>.- Characteristics of all radar output signals, as measured at the Control and Interface Assembly across 75 ohms termination shall be as follows:

Videos

Rise Time	*NMT 0.1 microsecond
Decay Time	NMT 0.1 microsecond
Overshoot-undershoot	NMT 10%
Droop (200 microsecond pulse)	NMT 10%
Duration (isolated target)	0.6 $\pm$ 0.1 microsecond
Amplitude - Adjustable, 2 to 8V positive	
Base line reference	0 $\pm$ 0.2 VDC
Jitter (referenced to aligned pre-trigger)	NMT 0.05 microsecond

connect the beacon output video to the remoting system. All coaxial jacks shall be installed on a panel which can be either grounded or ungrounded as the requirements of associated equipments may dictate. A barrier terminal strip (one each 20 terminal) shall be provided to accommodate beacon control wiring; terminal strips, as required, shall also be provided for the intercommunications system wiring.

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Duration (isolated target)	0.6 ± 0.1 microsecond
Amplitude - Adjustable, 2 to 8V positive	
Base line reference	0 ± 0.2 VDC
Jitter (referenced to aligned pre-trigger)	NMT 0.05 microsecond

3.15.2.3.1 Line driver.- The video line driver shall combine the normal video and radar pre-trigger into a composite, positive going signal and provide amplification as necessary to drive up to 20,000 feet of 75 ohm coaxial cable. The ratio of trigger amplitude to video amplitude shall be at least 3:1 to allow separation of the two at the remote site on an amplitude basis. A separate line driver channel shall be provided to amplify the MTI video as required to drive a second 75 ohm 20,000 foot coaxial cable. The line drivers shall be installed in the control and interface assembly. For single radar channel operation, the line driver in use shall be the one associated with the active radar channel; for dual diversity operation, the line driver in use shall be the one associated with the master radar channel. The output amplitude of the line drivers shall be adjustable from a minimum of 2.0 volts up to that level required to meet performance requirements at the end of 20,000 feet of 75 ohm coaxial cable. Video remoting cables will be electrically equal to RG-216/U.

3.15.2.3.2 Line compensator.- The line compensators shall be installed at the remote site and provide interface between the remoting cables and the remote site equipment (displays, video mappers, etc.). The input of the two line compensators may be paralleled across the remoting cables, provided that the cables are properly terminated and that faults in the input circuitry of one compensator do not affect operation of the other compensator. Provision shall be made to switch-select the output of either line compensator. Each line compensator-amplifier shall separate the normal video and trigger and provide two isolated outputs for each, as well as for the MTI video. The line compensators shall provide line equalization and amplification as required to restore the output signals to the characteristics listed in 3.15.2.2.1 for any length of 75 ohm coaxial remoting cable up to 20,000 feet. The line compensator-amplifier shall provide a minimum of 30 dB of common mode rejection. One set of outputs from each line compensator-amplifier (normal video, MTI video, aligned pre-trigger) shall be routed to a selector switch which shall select one or the other line compensator-amplifier as the active unit. The selected videos and trigger shall be routed to a video-trigger distribution assembly. The second set of outputs from each line compensator-amplifier shall be routed to a second selector switch which will select one or the other line compensator-amplifier as the signal source for a maintenance PPI display. There shall be no evidence of interaction between the two line compensator-amplifiers, or between the two sets of isolated outputs on each line compensator-amplifier, regardless of the status of either selector switch. It shall be possible to physically remove the unselected line compensator amplifier from the equipment rack for servicing without affecting system operation; however, maintenance features shall be provided as required to perform all routine maintenance with the unit installed.

3.15.2.3.3 Video/trigger distribution assembly.- This unit shall accept the video and trigger signals from the selected line compensator amplifier and provide multiple outputs for use by external equipment. Video distribution shall be separate from trigger distribution. Four video distribution amplifier modules shall be bridged across the video output lines from the line compensator-amplifier selector switch. Space shall be provided for two additional modules. The input impedance of the video distribution amplifier modules shall be sufficient that up to two modules can be added or removed from the basic complement of four without apparent change in the output signals from the installed modules. Each video distribution amplifier module shall provide variable amplification as required to produce 2 V positive MTI and normal video of the quality specified in 3.15.2.2.1 at the end of any length of RG-59 or equal coaxial cable up to a maximum of 300 feet. Four trigger distribution amplifier modules, each providing two isolated trigger outputs, shall be bridged across the trigger output line from the line compensator-amplifier selector switch. Space shall be provided for two additional modules; the input impedance of the trigger distribution amplifier modules shall meet the same criteria as that of the video distribution amplifier modules. The trigger distribution amplifier modules shall produce triggers as specified in 3.15.2.2.1 at the end of 300 feet of RG-59 coaxial cable or equal. A gain control is not required on the trigger distribution amplifiers. There shall be no evidence of cross coupling between the normal and MTI video signals, or between the videos and the trigger. Both the video and trigger distribution amplifiers shall provide sufficient isolation that improper terminations, ranging from a short to an open circuit, on one or more outputs will not cause damage to the module(s) so terminated, or be reflected in the outputs of the remaining modules.

3.15.2.3.4 Azimuth data pulse amplifier.- Two each azimuth data pulse amplifiers shall be provided and installed in the Control and Interface Assembly. Each azimuth data pulse amplifier shall accept the ACP and ARP signals from one of the dual Azimuth Pulse Generator (APG) units (3.8.9.3) and provide two isolated outputs of each signal. One ACP/ARP output set shall be shaped and amplified as required for remoting up to 20,000 feet over shielded twisted pair No. 19 AWG cable. The output level shall be adjustable from a minimum of 1V up to that level required by the maximum remoting distance. The second ACP/ARP output set from each amplifier shall be shaped and amplified as specified in 3.15.2.2.1 to provide azimuth synchronization for the maintenance monitor at the local site. Provision shall be made within the Control and Interface Assembly for manually patching either amplifier to the various points required at the local site.

3.15.2.3.5 Azimuth data pulse shaper amplifiers.- Two each azimuth data pulse shaper amplifiers shall be provided for installation at the remote site. Each amplifier shall accept the remoted ACP/ARP data from a separate set of remoting lines and amplify and shape the data to produce the characteristics specified in 3.15.2.2.1. Two sets of isolated outputs shall be provided on each pulse shaper amplifier. One ACP/ARP set from each pulse shaper amplifier shall be routed to a selector switch which shall select one or the other amplifier for synchronization of the system. The second set of output data from each amplifier shall be routed to a second selector switch which shall select one or the other amplifier for synchronization of a PPI maintenance monitor. The ACP/ARP data selected for system synchronization shall be routed to a distribution amplifier assembly.

3.15.2.3.6 Azimuth data distribution amplifier assembly.- This assembly shall accept the selected ACP and ARP data and provide isolation and amplification as required to produce data as specified in 3.15.2.2.1 at the end of any length of RG-59 or equal up to a maximum of 300 feet. Four distribution amplifier modules, each with two isolated ACP/ARP outputs shall be bridged across the lines from the selector switch. The input impedance and isolation characteristics of each module shall be as specified for the video and trigger distribution amplifiers (3.15.2.2.3).

3.15.2.3.7 Remote site equipment power supplies.- All remote site equipment except the remote control panels (3.15.1.9) shall be powered by a common, dual set of power supplies. The power supplies shall be configured as specified for the control power supplies (3.15.1.10) and in addition, shall be in full compliance with 3.17.1.8 and subparagraphs except that they shall operate from a 120V AC single phase source.

3.15.2.3.8 Remote site equipment cabinet.- All of the remote site equipment including one system control panel (3.15.1.9), the line compensator-amplifiers (3.15.2.3.2), the video/trigger distribution assembly (3.15.2.3.3), the azimuth data pulse shaper amplifiers (3.15.2.3.5), the azimuth data distribution amplifier assembly and the power supplies shall be installed in a single cabinet not to exceed 22 inches in width and depth and 76 inches in height. All external connections to the cabinet, except for remote control wiring, shall be made on a jack panel near the top front and accessible from the front. Full access to all installed units for maintenance or installation shall be provided from the front of the cabinet, so that it may be installed backed against a wall.

3.15.2.4 Microwave link remoting.- Provisions shall be made for remoting by means of microwave link in lieu of or in addition to the land line remoting previously specified. As in the case of land line remoting, the point of interface between the radar system and the microwave link at both the local and remote sites is the RCJB. BNC bulkhead feed-through connectors shall be installed in the local site RCJB to accommodate both land line and microwave link remoting of normal, MTI and beacon videos and radar trigger. The Control and Interface Assembly shall provide isolated outputs of normal and MTI video and aligned radar pretrigger for routing to a microwave link via the RCJB. The video levels shall be adjustable between 2.0 and 4.0 V positive; the trigger amplitude shall be not less than 15V positive, and need not be variable. No changes to the control wiring are necessary for microwave link remoting. At the remote site, provision shall be made to feed the video and trigger distribution assemblies directly from the microwave link, by-passing the line compensating and trigger separation circuitry.

3.16 Maintenance facilities.- In addition to built-in test equipment and other maintenance features specified elsewhere in this specification, the facilities specified in subparagraphs hereunder shall be provided.

3.16.1 Instruction books.- Instruction manuals shall be prepared and furnished in accordance with FAA-D-638 except that Section 12 of the instruction book (3.25, FAA-D-638) shall be furnished as a separately bound volume to be used as a trouble shooting manual. This trouble shooting manual shall be in accordance with all requirements of FAA-D-638 applicable to Section 12 (particularly those of 3.45 and subparagraphs) and in addition shall meet the requirements specified in subparagraphs hereunder.

3.16.1.1 Contents of trouble shooting manual.- The trouble shooting manual shall include all material required by 3.45 and subparagraphs of FAA-D-638 in the specified formats. In addition, it shall contain simplified, large scale diagrams designed to facilitate the rapid isolation of troubles within the system. These diagrams shall illustrate, in simplified form (block diagrams, logic diagrams, for example) the complete paths for such signals as radar video and trigger, RF signal flow and generation, etc. Comprehensive block diagrams showing interconnection of all equipment groups and of major subassemblies within equipment groups shall be provided, with signal paths identified. The simplified diagrams shall include sufficient test points together with applicable waveforms as are necessary to trace signals through the system and isolate troubles to a single block. Each block shall be fully identified, and shall include the page number or figure number of the complete schematic. Separate simplified diagrams shall illustrate AC power distribution, DC power distribution, control circuitry, metering circuitry, etc., and shall include all switches, fuses, circuit breakers and relays. The trouble shooting manual shall be arranged in a logical manner, and a comprehensive table of contents shall be included. Where different unit numbers are assigned to a single unit that is used repetitively, as for example, a power supply regulator card, cross referencing shall be provided as necessary to enable the schematic to be easily located by use of any of the applicable unit numbers.

3.16.1.2 Construction and binding.- All diagrams shall be flat and not folded (no tip-in sheets), and of heavy, serviceable stock to withstand the wear and tear of continuous usage. Diagrams shall be printed on only one side of the sheets. Sheets shall not exceed 11 by 20 inches in size. The trouble shooting manual shall be bound along the long dimension in such a manner that it can be opened to any desired page and folded open so as to lay flat for ready reference during maintenance use.

3.16.1.3 Review and acceptance.- The trouble shooting manual shall be subject to the same procedures for review and acceptance as is specified in FAA-D-638 for other sections of the instruction book.

3.16.2 Maintenance PPI.- One each plan position indicator shall be furnished for maintenance of the radar. The maintenance PPI shall utilize a 16-inch P7 phosphor cathode ray tube with electrostatic focusing and electro-magnetic deflection. Deflection shall be accomplished by fixed yoke. Sweep ranges of 10, 30, and 60 nautical miles shall be provided and shall be selected by means of a range selector switch. The PPI shall utilize the ACP-ARP data directly for azimuth synchronization.

Selectable range marks which intensity modulate the sweep and describe circles as the sweep rotates shall be provided at intervals of 1 and 5 nautical miles on all sweep ranges up to 60 nautical miles. When the 1 mile to be used as a trouble shooting manual. This trouble shooting manual shall be in accordance with all requirements of FAA-D-638 applicable to Section 12 (particularly those of 3.45 and subparagraphs) and in addition shall meet the requirements specified in subparagraphs hereunder.

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3.16.2.3 Power supplies.- The maintenance PPI power supplies may operate from one phase of the 3 phase primary power. Compliance with paragraphs 3.17.8.1, 3.17.8.2 and 3.17.8.6 is not required; however, the power supplies shall be designed and fabricated as necessary to result in PPI performance as specified over the range of service conditions.

3.16.2.4 Auxiliary features.- An edge lighted 360° compass rose shall be provided and a rotatable amber navigating head shall be provided. The navigating head shall have one engraved line across the diameter and engraved lines parallel to the centered line, at 2 inch intervals both sides of the centered line. A hood shall be provided to permit viewing the display in a lighted room.

3.16.2.5 Connections for maintenance PPI.- Appropriate connections shall be provided for all inputs (including power) for the maintenance PPI on the front of each processor cabinet. These connectors shall be available with the cabinet door closed. Connector covers with captive chains shall be provided for each connector. One complete, durable, prefabricated cable of a length recommended by the contractor and approved by the Government shall be furnished to make all external connections.

3.16.2.6 Connection provisions.- Separate connectors shall be provided and mounted on the PPI for the following:

1. MTI video
2. Normal video
3. Beacon video
4. Azimuth position data
5. Trigger
6. Power

3.16.2.7 Cart.- A cart shall be furnished on which to place the maintenance PPI. The cart shall have an attractive appearance and shall harmonize with the cabinets in construction and finish. It shall be equipped with rubber-tired wheels of sufficient size (minimum of three inches) to provide smooth travel over a concrete floor. All four wheels of the cart shall be free to rotate in any direction for maximum mobility. The cart shall be provided with a power cord of sufficient length to reach the convenience outlets of each equipment where it is used. The cart shall be provided with at least two convenience outlets for test equipment. The cart shall hold the PPI at an optimum angle for viewing by a technician while standing.

3.16.3 Video and trigger switch panel.- Two jack connectors with associated selector switches located on the same panel shall be provided in each cabinet to permit convenient viewing of selected waveforms and for selected trigger connections. Normal video, MTI video, and bi-polar video, for example, shall be available through an associated selector switch at the processor

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Government that this is impracticable or unnecessary. Maintenance adjustment controls shall employ small knurled knobs. Where the special nature of a function makes a large knob or screwdriver slot desirable, the use of such controls shall be subject to specific Government approval. Motor driven switches and controls are prohibited except for waveguide switches, motor-driven auto transformers, and antenna polarization control.

3.17.1.3.1 Location of controls.- Frequently used controls on plug-in modules and cards shall be accessible without removal of the module from its normal position. Controls on units using vertical panel construction shall be on the front surface of the panel of the unit with which the control is associated. Controls for horizontal chassis units shall be mounted on front panels or immediately behind front access panel doors of each unit. All controls shall be mounted so as to minimize the possibility of personnel coming in contact with high voltages or components operating at a high temperature or both.

3.17.1.4 Relays.- In addition to the requirements of FAA-G-2100/1, relays utilized in the system (excluding contactors) shall meet the following requirement. A circuit diagram shall be provided for each relay. All chassis-mounted relays shall be of the plug-in type. The number of different relay types used shall be held to an absolute minimum. Each DC relay coil shall have a suitable damping diode or other device to eliminate transients.

3.17.1.5 Terminal blocks and connectors.- Each module/card bin, vertical chassis, and cabinet shall be equipped with connectors, or barrier type terminal blocks, or both, for the termination of inter-unit and inter-cabinet cabling. The terminals of all terminal blocks shall be covered with removable clear plastic strip barriers having round access holes in line with each terminal to permit the insertion of a screwdriver blade or test probe.

3.17.1.6 System grounding.- A common system grounding design shall be used for all units to be delivered under this specification. Line filters, if used, shall not introduce currents in the grounding system. The grounding design shall contain three discrete ground busses:

(a) One that bonds together all cabinets and frames.

(b) One that connects all video and trigger signal return wires together.

(c) One that connects all power grounds together.

The cabinet/frames (a) and the signal return (b) ground busses shall be isolated from the power ground (c) and also isolated from building (earth) ground except that both busses (a) and (b) are to be connected to the building ground at one common connection point. Signal return paths for signals that pass between units/channels shall use the shield of the coaxial cable, or a separate signal return wire shall be provided for each path if coaxial cable is not required. The power grounding system (c) shall be separate from the other two busses. All internal equipment ground wires shall be at least 500 circular mills per lineal foot but not less than 1000 circular mills. The portions of ground busses (a) and (c) external to equipment cabinets shall be stranded copper, #6 AWG or larger.

3.17.1.7 Video switching.- To the extent possible, all video and trigger selection or switching shall be accomplished by means of solid-state switching devices in lieu of electro-mechanical relays. No adverse effects shall occur at any point in the system as a result of impedance mismatch during switching. Proper termination of all switched functions shall exist for all possible switched states.

3.17.1.8 DC power supplies.- All power supplies shall employ solid-state devices exclusively both in rectifier and voltage regulating circuits. All power supplies shall be three phase. Power supplies shall be modular in nature, at least to the extent that a separate power supply module is furnished for each required voltage. Each module shall include protective fusing or a circuit breaker and status indicator. All power supplies shall be sufficiently decoupled from loads to prevent any interaction or cross-coupling between loads. The overall equipment design shall be such as to minimize the number of separate types of power supplies. All power supplies shall be field repairable. The above requirements and those of subparagraphs hereunder apply to all power supplies except as specifically noted in the individual power supply requirements. In addition, compliance with paragraphs 3.17.1.8.1 through 3.17.1.8.4 is not required of high voltage power supplies associated with the transmitter/modulator assembly and the klystron solenoid power supply. These power supplies shall be designed and fabricated as required to meet all other specified requirements over the range of service conditions.

3.17.1.8.1 Regulation.- All power supplies shall be electronically regulated to maintain output voltages within ± 1% as the load is varied from 20% less than to 50% more than the normal load, and as the line voltage is varied between service condition limits, with primary power line regulators (if used) in the circuit. The output voltages of these regulated supplies shall be adjustable to any value over a range of ± 10% of the nominal value, and the regulation and ripple specifications shall be met for any and all settings within this range. Power supply output voltage shall not change by more than ± 1% from the initial setting over the service conditions. The regulation and ripple requirements are minimum requirements, and it shall be the contractor's responsibility to design the equipment with such additional reduction in ripple and improved regulation as is required to meet all specified performance requirements. A separate, independent voltage reference solid-state device shall be used for each regulated power supply voltage, and the regulation of one power supply voltage shall not depend on another power supply voltage for reference.

3.17.1.8.2 Ripple voltage.- Ripple voltages, defined as the peak-to-peak value of a simple or complex waveform consisting of power line frequency components and harmonics thereof, and/or synchronous or repetitive coaxial cable is not required. The power grounding system (c) shall be separate from the other two busses. All internal equipment ground wires shall be at least 500 circular mills per lineal foot but not less than 1000 circular mills. The portions of ground busses (a) and (c) external to equipment cabinets shall be stranded copper, #6 AWG or larger.

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3.17.1.8.1 Regulation.- All power supplies shall be electronically regulated to maintain output voltages within ± 1% as the load is varied from 20% less than to 50% more than the normal load, and as the line voltage is varied between service condition limits, with primary power line regulators (if used) in the circuit. The output voltages of these regulated supplies shall be adjustable to any value over a range of ± 10% of the nominal value, and the regulation and ripple specifications shall be met for any and all settings within this range. Power supply output voltage shall not change by more than ± 1% from the initial setting over the service conditions. The regulation and ripple requirements are minimum requirements, and it shall be the contractor's responsibility to design the equipment with such additional reduction in ripple and improved regulation as is required to meet all specified performance requirements. A separate, independent voltage reference solid-state device shall be used for each regulated power supply voltage, and the regulation of one power supply voltage shall not depend on another power supply voltage for reference.

3.17.1.8.2 Ripple voltage.- Ripple voltages, defined as the peak-to-peak value of a simple or complex waveform consisting of power line frequency components and harmonics thereof, and/or synchronous or repetitive

<u>3.17.1.9 Electromagnetic interference and susceptibility</u>.- The equipment shall be designed and constructed to meet the interference and susceptibility requirements of Military Standards MIL-STD-461A (and Notice 3) and 462 (and Notice 2) for Class A3 equipments. The contractor shall prepare and submit, within 90 days after award of the contract, an interference control plan detailing the contractor's intent and methods in satisfying the applicable requirements of the interference standards. The plan shall be in accordance with paragraph 4.2 of MIL-STD-461A and Notice 3.

<u>3.17.1.10 Surge protection</u>.- Protective devices shall be provided as necessary to prevent damage to the equipment from surges on either the AC power lines, the remoting lines, or both. The protective devices shall be capable of limiting initial spikes as might result from nearby lightning strikes to a value that will not damage any equipment. The protective devices shall be capable of withstanding repeated surges without damage or change in operating characteristics. This requirement is in addition to the surge protection specified in FAA-G-2100/1.

3.18 Packaging and construction.- The basic packaging concept of the equipment shall be small plug-in modules and printed circuit boards to the extent practicable, mounted in standard cabinets (3.18.1). The structural strength and rigidity of equipment units and cabinets shall be such that normal handling in loading, shipping, unloading, and setting into position for installation, as well as movement over-the-road with the equipment installed in transportable buildings, will not result in any mechanical damage, or in any way degrade the operation, appearance or maintainability of the equipment. At least 10% of the front panel of each equipment cabinet, together with the interior cabinet space behind it, shall be left unused. Blank panels shall be furnished and installed for any unused space.

3.18.1 Cabinet design.- Equipment cabinets, except as noted in 3.10.1, shall be of uniform size, not to exceed 80 inches in height and 30 inches in depth and width. All cabinets shall be of high quality, sturdy construction, accurately and carefully fabricated, with facilities for bolting or fastening to the floor. Ventilation air shall enter at the lower front and exit from the cabinet top, with the air exit screened or otherwise protected to prevent small objects from falling into the cabinet. Access to the cabinet interior shall be from the front only, with full width, latching access doors extending from near the top of the cabinet down to the air inlet. Access doors shall be mounted by slip-pin hinges so that the doors may be easily removed. The hinges shall be adjustable, and secured to the cabinets by means of screws or nuts and bolts. All cable and waveguide access shall be at the top of cabinets. All wiring entering the cabinet shall terminate on blocks near the top front of the cabinet and accessible either through the main access door or a small removable panel. Panels, chassis, and modules/card bins shall be adequately supported within the cabinets and of a size and weight as will permit removal and replacement by one technician. Convenience outlets (1-3.6.4, FAA-G-2100/1) shall be provided on the lower front of each cabinet.

3.18.1.1 Overheat warning devices.- As a minimum, each cabinet shall be provided with a temperature sensor located just inside the air exhaust outlet. Sensing of a temperature rise in excess of the design limit (normally the maximum ambient temperature plus the cabinet rise above ambient permitted by FAA-G-2100/1) shall be indicated by a warning light conspicuously located on the cabinet, as well as by a channel fault light. Additional temperature sensors and air flow switches shall be provided as necessary to protect the system from damage.

3.18.1.2 Cabinet illumination.- Shielded lights for general illumination of the cabinet interiors shall be provided. These lights shall be turned on by opening of the cabinet access door, and turned off by closing of the door. With the door open, manual control of the lights shall also be possible. If meters, controls, test points, etc., are visible or accessible with the access doors closed, additional lighting shall be provided as is required to make them readily visible with the room lights turned off. Manual control of these lights shall be provided.

3.18.1.3 Front panel connectors and cables.- Front panel connectors and cables shall be limited to those required for testing, or where it is not feasible to utilize rear connectors.

3.18.1.4 Grounding rods.- Adequately insulated grounding rods with a connecting grounding strap permanently affixed to good cabinet grounds shall be provided and installed on hooks inside the doors of all cabinets which contain voltages (other than primary AC power) in excess of 150 volts to enable maintenance personnel to ground all points which are potentially hazardous before performing equipment maintenance. Caution plates shall be installed in appropriate locations to remind maintenance personnel to utilize the grounding rods before performing any maintenance on the equipment.

3.18.1.5 Transmitter cabinet components.- Large components in the transmitter modulator and high-voltage power supply portions of the equipment may be mounted on a horizontal chassis, mounted horizontally at floor level, or mounted on cabinet walls provided they are adequately supported and all mounting fasteners, terminals, and associated wiring for such components are easily accessible for maintenance testing and repair through the front access door without requiring removal of the chassis.

3.18.2 Ventilation and cooling equipment.- All blowers, vents and other cooling equipment necessary for the proper operation of the equipment over the range of the service conditions (3.2) shall be provided. Each cabinet shall contain its own blower system and, except for the transmitter cabinet, shall require no external ducts. With the access doors of any or all cabinets open for up to eight hours, the equipment shall not overheat, develop hot spots or become unstable in operation.

3.18.2.1 Ventilation blowers.- All primary cabinet blowers shall be three phase, continuous duty type. Small auxiliary blower motors, as for example might be employed for moving air directly through the heat sink of a power supply, may be single phase provided, however, that they do not exceed 0.1 horse power in capacity. All blower motors shall be equipped with sealed, permanently lubricated bearings.

3.18.3 Modular concept.- The configuration of the modular assemblies shall be one of the following:

(a) Standard rack mounting slide-out drawers or chassis. Drawer slides shall be heavy-duty locking type to permit locking the drawer or chassis in either the normal closed or extended position. Printed circuit cards or modules shall be mounted vertically in the drawers/chassis.

(b) Standard rack mounting assemblies with shelf mounted modules that plug into a front panel/chassis assembly. Printed circuit cards or modules shall be mounted vertically.

3.18.3.1 Plug-in modules.- Plug-in modules and plug-in printed circuit card modules shall be designed for mounting in card bins or module bins. Plug-in modules shall have a metal chassis or other suitable framework to provide a

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4.2.2 Normal test conditions.- The following design qualification tests shall be made under normal test conditions:

Test

(a) Antenna, Static load test

Only one antenna shall be static load tested to determine compliance with requirements for maximum wind velocities and iced conditions. The contractor shall submit a detailed description of the proposed static load test for Government approval.

4.3 Type tests.- The tests listed below (4.3.1 and 4.3.2) shall be performed in addition to the requirements of 1-4.3.3, 1-4.3.3.1, and 1-4.3.3.2 of FAA-G-2100/1. All service condition tests shall be made using the channel of the radar system selected by the Government. Test data shall be recorded for this channel. Spot-check tests shall also be made on the standby channel during the process of testing the operating channel and shall include the observation of the proper functioning of the channel selector switches and changeover equipment. If such spot checks should indicate that the channel selector switches or the standby channel is not performing satisfactorily, all malfunctioning of the system shall be properly corrected and all service condition tests shall be repeated using the former standby channel with spot-checks on the former operating channel, and all such information and data shall be recorded on the test data sheets. Complete systems or additional items of equipment scheduled for shipment subsequent to the system being type-tested shall not be shipped from the contractor's plant without Government approval until all the type tests have been completed on one system and the type-test results have been accepted as satisfactory by the Government.

4.3.1 Service conditions.- The following type tests as a minimum shall be made while subjecting the equipment to the test procedure described under 1-4.12 of FAA-G-2100/1:

Test

(a) Antenna driver operation

(b) Transmitter frequency

(c) Transmitter peak power - maximum and normal operating

(d) RF pulse width and pulse shape

(e) Transmitter output RF spectrum

(f) Receiver performance (Normal and MTI)

(g) Log-FTC-anti-log performance (Normal and MTI)

(h) Receiver sensitivity (Normal and MTI)

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(e) Transmitter output RF spectrum

(f) Receiver performance (Normal and MTI)

(g) Log-FTC-anti-log performance (Normal and MTI)

(h) Receiver sensitivity (Normal and MTI)

(e) Integrated cancellation ratio

*(f) Transmitter frequency

*(g) Transmitter peak power - maximum and normal operating (using calorimeter method and water load)

*(h) Transmitter PRF

*(i) Transmitter RF pulse width and shape

*(j) Transmitter RF spectrum

(k) Receiver performance (Normal and MTI)

(l) IF bandwidth (Normal and MTI)

(m) Overall video bandwidth and pulse response (Normal and MTI)

*(n) Receiver sensitivity (Normal and MTI)

(o) Parametric amplifier

(p) Overall gain (Normal and MTI)

(q) Radio frequency generator performance

*(r) Synchronizer

*(s) Receiver gain control unit (Normal and MTI)

(t) Log-FTC-anti-log performance (Normal and MTI)

*(u) Video enhancer (Normal and MTI)

*(v) Velocity shaping canceller

*(w) PRF staggering

(x) RF mixer and phase control

*(y) Power supply regulation, ripple, voltage range, and performance

(z) Operation of switching and control functions

(aa) Channel change time

(bb) Cross-channel interference elimination

*(cc) All meter readings

(e) Integrated cancellation ratio

*(f) Transmitter frequency

*(g) Transmitter peak power - maximum and normal operating (using calorimeter method and water load)

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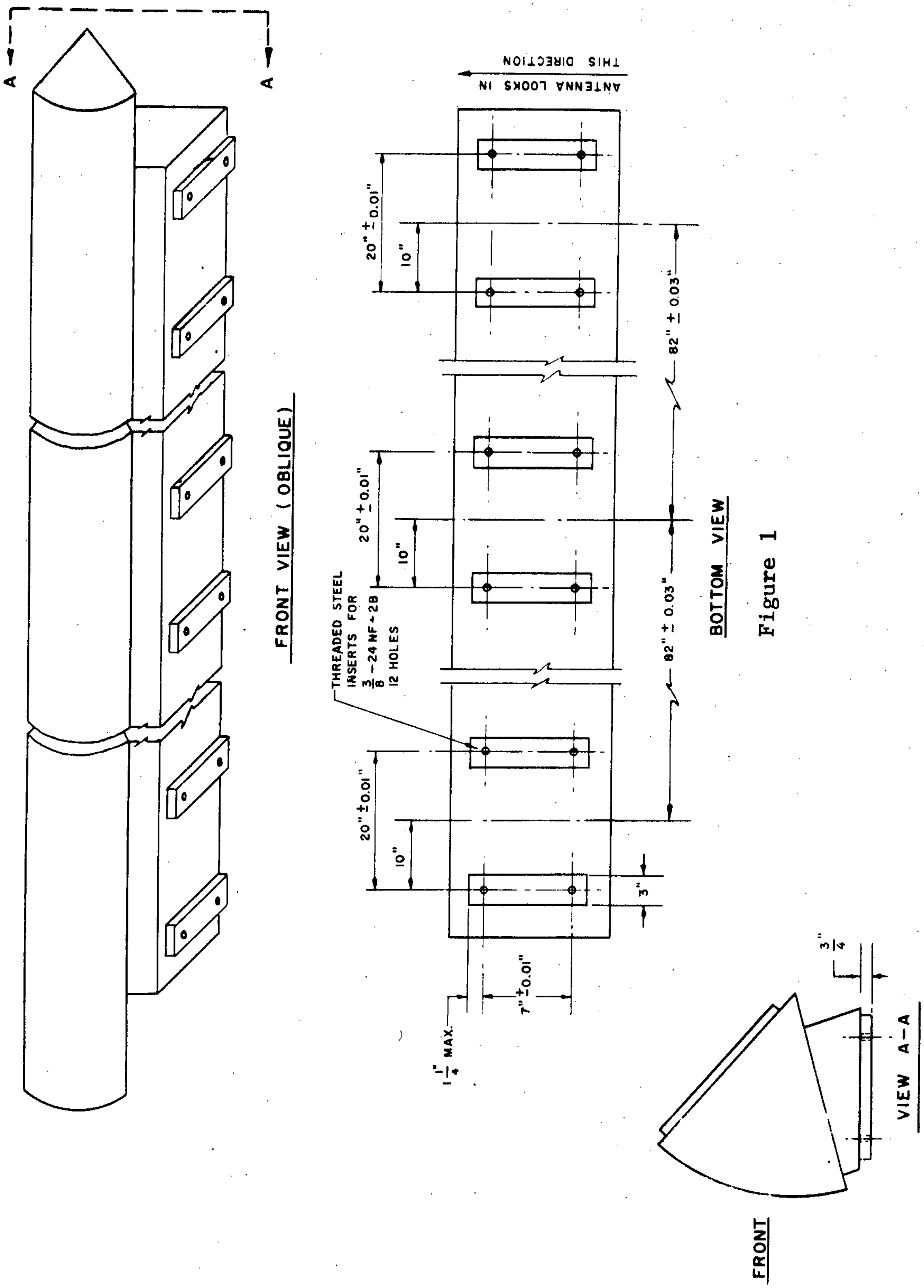
*(cc) All meter readings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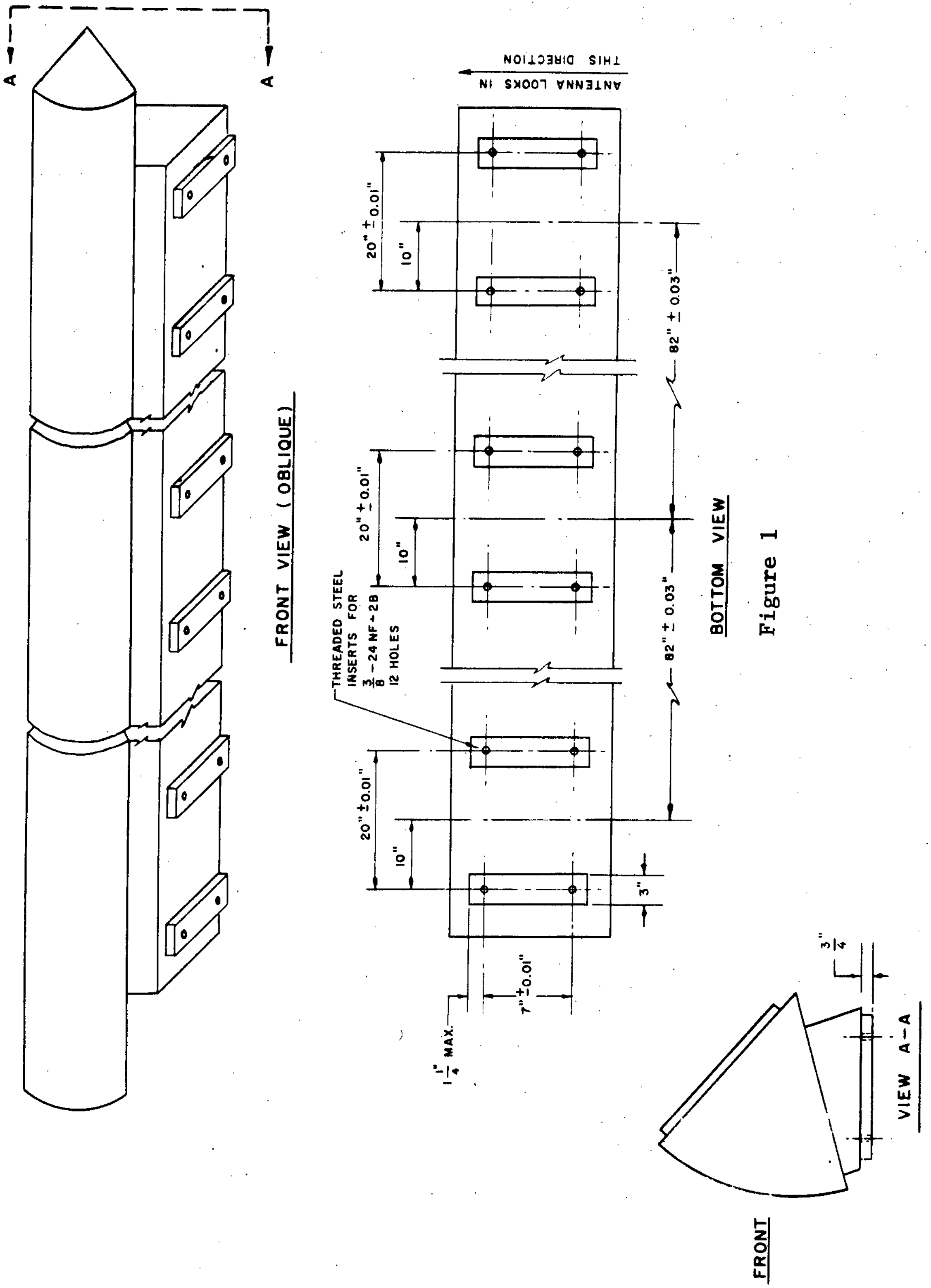
FRONT VIEW (OBLIQUE)
ANTENNA LOOKS IN THIS DIRECTION
20" ± 0.01"
10"
82" ± 0.03"
THREADED STEEL INSERTS FOR 3/8 -24 NF-2B 12 HOLES
3"
7" ± 0.01"
1 1/4" MAX.
BOTTOM VIEW
3/4"
VIEW A-A
FRONT

Figure 1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BOTTOM VIEW
3/4"
VIEW A-A
FRONT

Figure 1

plane and not less than 16 dB at the principal azimuth plane. The level of the cross polarized component at points not specified shall have values not greater than that required to have a direct linear relationship to the elevation angles between adjacent specified points."

Change paragraph 3.9.12 as follows:

Delete the second and third sentences and substitute the following: "The ICR of the antenna for the patterns associated with the main feed horn and passive feed horn shall be at least 22 dB in the principal azimuth plane, 17 dB at an elevation range of 5^{o} above the principal azimuth plane, 10 dB at an elevation angle of 30^{o} above the principal azimuth plane for the main feed horn and 28^{o} above the principal azimuth plane for the passive feed horn. The ICR shall be at least 17 dB for the normal pattern and 14 dB for the passive pattern at the underside -6 dB one-way power strength of each elevation pattern. In addition the ICR shall be at least 4 dB in the azimuth plane at the elevation angle of the underside -20 dB one-way power strength of the pattern associated with the passive feed horn."

On page 34, at the end of paragraph 3.10.7.2, add the following:

"If the modulator design precludes maintenance by means of a dummy load, the following troubleshooting aids and maintenance devices shall be provided as a minimum. Test points for viewing voltage and current waveforms, indicator lights, metering, etc., shall be provided as necessary to diagnose and isolate any faulty parts. The klystron tank compartment shall be designed for accessibility and maintainability. If draining of the oil is necessary to gain access to tank mounted parts, a mobile oil tank with reversible pump system and quick disconnect fittings shall be furnished."

Page 40, paragraph 3.11.5.2, change this paragraph to read as follows:

"The IF bandwidth of the normal portion of the receiver shall be optimum for the type of IF filter used but not greater than 1.4 divided by the pulse-width."

Delete paragraph 3.15.2.3.3 and substitute the following:

"3.15.2.3.3 Video/trigger and azimuth data distribution assembly.- This unit shall accept the video and trigger signals from the selected line compensator amplifier and accept the ACP and ARP data from the selector switch and provide multiple outputs for use by external equipment. The unit shall consist of three distribution amplifier printed ciruit boards bridged across the video output lines from the line compensator-amplifier selector switch or APG pulse shaper selector switch as appropriate. The input impedance of the distribution amplifiers shall be sufficient such that up to two distribution amplifier

PCBs can be removed without apparent change in the output signals from the installed distribution amplifier PCB. Each distribution amplifier shall accept MTI and normal video, trigger, ACP, and ARP inputs and provide the following outputs each isolated from all others: 2 MTI videos, 2 normal videos, 4 triggers, 4 ACPs, and 4 ARPs. Each video output amplifier shall provide variable amplification as required to produce 4V positive video of the quality specified in 3.15.2.2.1 at the end of any length of RG-59 or equal coaxial cable up to a maximum of 300 feet. The trigger amplifiers shall produce triggers as specified in 3.15.2.2.1 at the end of 300 feet of RG-59 coaxial cable or equal. A gain control is not required for the trigger amplifiers. The ACP and ARP amplifiers shall provide isolation and amplification as required to produce data as specified in 3.15.2.2.1 at the end of any length of RG-59 or equal up to a maximum of 300 feet. There shall be no evidence of cross coupling between the normal and MTI video signals, or between the videos and the trigger. All output amplifiers shall provide sufficient isolation that improper terminations, ranging from a short to an open circuit, on one or more outputs will not cause damage to the amplifier(s) terminated, or be reflected in the outputs of the remaining amplifiers."

Delete paragraph 3.15.2.3.6 and substitute the following:

"3.15.2.3.6 Unused."

Revise the first sentence of paragraph 3.15.2.3.8 to read as follows: "All of the remote site equipment including one system control panel (3.15.1.9), the line compensator-amplifiers (3.15.2.3.2), the video/trigger and azimuth data distribution assembly (3.15.2.3.3), the azimuth data pulse shaper amplifiers (3.15.2.3.5), and the power supplies shall be installed in a single cabinet not to exceed 22 inches in width and depth and 76 inches in height."

Revise paragraph 3.16.1, first line on top of page 71 to read as follows:

"to be used as a trouble shooting manual and Section 10 Parts List which shall be in accordance with the following subparagraphs. This trouble shooting manual".

Insert the following new paragraphs after 3.16.1.3:

"3.16.1.4 Parts List.- This section shall contain a tabulation (reference FAA-D-638, paragraph 3.43.1) of descriptive data on all electrical parts (defined in 3.43.2 of FAA-D-638) and certain mechanical parts (defined in 3.43.3 of FAA-D-638) of the equipment. For single-unit equipment having reference designations not prefixed by a unit number, the tabulation shall be arranged in alphabetical-numerical order of reference designations (defined

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(The JAN or MIL TYPE DESIGNATION shall be given in MIL specifications).

(The Federal Stock Numbers or National Stock Numbers obtained during prescreening shall be included in accordance with the following format:
FSN XXXX-XXX-XXXX
NSN XXXX-XX-XXX-XXXX)"

Add the following new paragraph after 3.18.3.9:

"3.18.3.9.1.- Non-axial-leaded parts (excluding transistors and integrated circuits) shall be mounted against or as close as possible to the printed circuit board."

Page 83, paragraph 3.18.3.11, after the first sentence add the following:

"A three phase power transformer may be used where isolation of the three phase power line is required for use within the transmitter cabinet. This transformer shall meet the requirements of MIL-T-27, Class R, Life Expectancy X, but shall be excluded from meeting sealing, immersion, vibration, and shock requirements of Grade 4 units. Material used in construction of the transformer shall meet the design requirements of MIL-T-27, Grade 4; however, air cooled open winding construction may be used provided that the transformer is physically located within the transmitter cabinet and a metal protective cover is provided. All other transformers shall meet the following requirements."

Delete the fifth sentence in paragraph 4.4 which states: "Spare units provided...." In lieu thereof, insert the following:

"Spare units provided with each system shall be installed and checked by replacing installed boards with all site spares and conducting onsite acceptance testing, after which the site acceptance testing will not be repeated with the set of boards originally installed in shipped equipments."

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FAA-E-2506 & AMEND.-4
SPECIFICATION CHANGE-2
April 27, 1977

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

AIRPORT SURVEILLANCE RADAR (ASR)
TRANSMITTER-RECEIVER (T/R) SUBSYSTEM

This specification change forms a part of FAA-E-2506 dated November 12, 1971, as modified by Amendment-4.

Change paragraph 3.17.1.9, fourth line, to read as follows:

"Notice 2) for Class A3 equipments with the following limit relaxations for CE-03 broadband and narrowband conducted emissions:

a. 20 dB relaxation from 20 KHz to 60 KHz broadband conducted emissions.

b. 15 dB relaxation from 60 KHz to 140 KHz broadband conducted emissions.

c. 10 dB relaxation from 1 MHz to 2 MHz broadband conducted emissions.

d. 10 dB relaxation from 20 KHz to 60 KHz narrowband conducted emissions.

e. 6 dB relaxation from 60 KHz to 140 KHz narrowband conducted emissions." #

* * * * * * *

FAA-E-2506 & AMEND.-4
SPECIFICATION CHANGE-2
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* * * * * * *

FAA-E-2506
AMENDMENT-4
November 19, 1975
SUPERSEDING
AMENDMENT-3, 8/29/73

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

AIRPORT SURVEILLANCE RADAR (ASR)
TRANSMITTER-RECEIVER (T/R) SUBSYSTEM

This amendment forms a part of FAA-E-2506 dated November 12, 1971.

Page 2, paragraph 2.1: Delete FAA-G-2100/5 as an applicable specification.

Page 3: Add new paragraph below existing paragraph 3.1.7 as follows:

"3.1.8 Nose of the beam.- The nose of the beam of the antenna is defined as the intersection of the principal azimuth plane with the principal elevation plane."

Page 4, paragraph 3.3.1: In next to last line, delete "modulator".

Page 4, paragraph 3.3.2: In the penultimate line, change the word "BLAKE" to read "NRL".

Page 4, paragraph 3.3.3, lines 4 and 5: Change to read as follows:

"These characteristics apply for both single channel and dual diversity operation, and throughout the frequency range of 2700 to 2900 MHz."

Page 5, paragraph 3.3.3: At end of receiver characteristics, add the following: "Receiver MDS figures apply for both main (low) and passive (high) antenna beam, and shall be measured at the coupler specified in 3.11.6.6. Selection of video enhancers shall result in MDS measurement at least equal to those specified herein." At end of antenna characteristics, add the following: "Overall VSWR (measured at input to rotary joint, all S-band paths) 1.4:1."

Page 6, paragraph 3.4.3: In tenth line, delete the words "by changing the basic clock frequency."

Page 7, paragraph 3.5.1: Delete second sentence in definition of Availability.

Page 11, paragraph 3.5.4.3.2: In second line, change "3.5.2.1" to "3.5.3.3.4".

Page 12, paragraph 3.5.4.3.3, second paragraph: Add the following between sentences two and three (eighth line):

"Preventative maintenance tasks shall be such that all such tasks shall be performed during a single period of activity, not more than once per day."

Page 12, paragraph 3.5.5: Change third line to read as follows:

"a. Simplex ASR radar MTBF (exclusive of antenna) 600 hours".

Page 13, paragraph 3.6, line item a.: Change "Control Assembly" to "Control System". In item m., change "3.16.1 and subparagraphs" to "3.16.2 and subparagraphs". At end of paragraph, add:

"p. 1 each Remote Site Equipment Cabinet (3.15.2.3.8)"

Page 14, paragraph 3.7.1: In second line, change "3.16.3" to "3.16.1".

Page 14, paragraph 3.7.2: In first line, change "3.16.3" to "3.16.1".

Page 14, paragraph 3.7.5: In second line, change "3.13.5" to "3.16.5".

Page 14, paragraph 3.8: Change line 4 to read: "circular/linear polarizers, and other features described herein or otherwise needed to".

Page 5, paragraph 3.3.3: At end of receiver characteristics, add the following: "Receiver MDS figures apply for both main (low) and passive (high) antenna beam, and shall be measured at the coupler specified in 3.11.6.6. Selection of video enhancers shall result in MDS measurement at least equal to those specified herein." At end of antenna characteristics, add the following: "Overall VSWR (measured at input to rotary joint, all S-band paths) 1.4:1."

Page 6, paragraph 3.4.3: In tenth line, delete the words "by changing the basic clock frequency."

Page 7, paragraph 3.5.1: Delete second sentence in definition of Availability.

Page 11, paragraph 3.5.4.3.2: In second line, change "3.5.2.1" to "3.5.3.3.4".

Page 12, paragraph 3.5.4.3.3, second paragraph: Add the following between sentences two and three (eighth line):

"Preventative maintenance tasks shall be such that all such tasks shall be performed during a single period of activity, not more than once per day."

Page 12, paragraph 3.5.5: Change third line to read as follows:

"a. Simplex ASR radar MTBF (exclusive of antenna) 600 hours".

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Page 14, paragraph 3.8: Change line 4 to read: "circular/linear polarizers, and other features described herein or otherwise needed to".

(c) Under static loading to simulate the combined effects of 1/2 inch radial ice and 130 knot wind (survival conditions) the reflector shall survive without damage and, after removal of the loading, deviation of the reflector surface contour from the true (design) contour shall not exceed ± 1/4 inch.

The simulated loadings above shall be determined to include the loadings caused with beacon antenna installed per paragraph 3.8.7.4 of this specification. The removable section of the reflector surface utilized for the test horn shall be removable from the rear and shall not distort the reflector contour when in place to the extent that antenna performance is affected."

Page 21, paragraph 3.8.8.1: Adjacent to item (c) Duty Cycle, change duty cycle for all S joints from "0.001" to "0.0015". Change sub-item (h) to read as follows:

	"S" Joint #1	"S" Joints #2 & 3	"S" Joints 4 & 5
(h) Attenuation (Max Insertion Loss)	0.2 dB	#2 0.5 dB #3 0.75 dB	1 dB

Page 23, paragraph 3.8.10: Change next to last paragraph as follows:

Item 1, place a period after MIL-C-5541 and delete the remainder of the sentence.

Item 3, change to read as follows: "3. Polyurethane Enamel per MIL-C-38412, Type II or Coating, Urethane, Aliphatic Isocyanate per MIL-C-83286; color International Orange, color number 12197 per FED-STD-595, thickness 0.0020 ± 0.0006 inches."

Page 23, paragraph 3.9: Next to last line on page, insert "(vertical)" between "linear" and "polarized".

Page 24, paragraph 3.9.1: Add the following at the end of the paragraph:

"The antenna shall have a median gain of -10 dB or less relative to an isotropic source measured in the principal radiation plane of the antenna patterns associated with the main and passive feed horns. Median gain is defined as the level over an angular region (in this case 360 degrees of the horizontal plane) at which the probability is 50% that the observed or measured gain at any position of the antenna will be less than or equal to that level."

(c) Under static loading to simulate the combined effects of 1/2 inch radial ice and 130 knot wind (survival conditions) the reflector shall survive without damage and, after removal of the loading, deviation of the reflector surface contour from the true (design) contour shall not exceed ± 1/4 inch.

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On page 32, delete the third through sixth sentences of paragraph 3.10.3.2 and substitute the following:

"The cooling system air intake shall be internal room air and shall be exhausted into the room and/or the air conditioning return air duct. In the event the exhaust air is returned into the room, the exhaust air flow shall be directed so as not to impinge on personnel. The air conditioner shall be of sufficient capacity to handle the total building and electronics heat load including the transmitter unit, but the transmitter cooling air flow shall not be in any way dependent upon the air conditioner for providing the volume of air required to cool the transmitter. In the event the air conditioner fails, the hot transmitter exhaust air shall not be recirculated back into the air conditioning supply duct, but may be exhausted along with other building air through the emergency exhaust port. The transmitter cabinet shall maintain a positive static pressure higher than the surrounding air pressure (FAA-G-2100/1 1-3.9.5) when the transmitter cabinet cooling system is on and maintain at least the same pressure as the ambient building pressure at all other times."

Page 33, paragraph 3.10.3.5: Line five, delete "necessitating." Last line, insert "be" between "shall" and "an".

Page 33, paragraph 3.10.3.5.2: Add the following at the end of the paragraph: "A wheeled cart or dolly designed to store a spare klystron plus a second klystron removed from a transmitter during maintenance shall be provided with each system. The cart or dolly shall include a plug-in ion pump power supply if required during klystron storage (3.10.3.6)."

Page 33, paragraph 3.10.5: Delete period at end of sentence and add "or modulator pulse."

Pages 33 and 34, paragraph 3.10.7: Delete the first two sentences and substitute the following: "The transmitter modulator shall be entirely solid-state and modular in nature so as to provide a fail-soft characteristic. The modulator shall consist of not less than eight nor more than 12 identical modules operating in parallel. At least 80% of klystron normal operating power (3.10.3) shall be maintained with two modules removed. This shall occur without resorting to any readjustment of klystron RF drive, modulator high voltage, etc. Temperature derating of critical modulator parts as specified in 3.5.3.3.6 shall be demonstrated as a design qualification test."

Page 34, paragraph 3.10.7.1: Last line, change "3.10.2.3" to "3.14.2.1".

Page 34, paragraph 3.10.7.2: Delete last sentence and substitute the following: "A voltage divider and video test jack shall be provided to permit observation of the modulator pulse with safety and convenience."

Page 34, paragraph 3.10.8: In next to last line, change "3.10.2.3" to "3.14.2.1".

Page 34, paragraph 3.10.8.1: In next to last line, delete "1.15 MW" and substitute "10 percent above normal operating power (3.10.3)."

Page 35, paragraph 3.10.9.1: At end of paragraph, add the following: "This switch is not required if arc protection is accomplished by removal of the beam voltage."

Page 35, paragraph 3.10.9.2: Delete text and substitute the following:

"Frequency tolerance of the radiated signal, including drift from a cold start over the range of service conditions, shall not exceed ± 100 parts per million."

Page 35, paragraph 3.10.10: Add the following under "10. Bias failure":

"11. Focus solenoid current;

12. Solenoid air flow

In addition, if an oil reservoir is provided as part of the klystron installation, a means of visually checking the oil level with the transmitter in operation shall be provided."

Page 36, paragraph 3.10.11: Delete the following: "6. Thyratron driver current (if tyratron used)" and "7. Thyratron driver inverse current (if thyratron used)". Change "8." in last line of paragraph to "6."

Page 37, paragraph 3.11.1.2: Change paragraph title and text to read as follows: <u>"3.11.1.2 Receiver Gain Control/STC/Antenna Beam Selector</u>.-Receiver RF gain, sensitivity time control (STC), and antenna pattern selection (main or passive) shall be accomplished by means of PIN modulators inserted in the two receive paths between the TR device (3.11.1.1) and the parametric amplifier (3.11.1.4). When biased for minimum attenuation, the resultant insertion loss of the PIN modulators in each receive path shall be as required to be compatible with a system noise figure of 4.0 dB or less. When biased for maximum attenuation, the characteristics of the PIN devices shall be as required to provide the receiver RF gain, STC, and beam isolation functions specified below. Separate and independent STC and receiver gain functions shall be provided in both the high beam (passive) and low beam (main) receive paths for each channel."

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Page 39, paragraph 3.11.1.5: Change first sentence to read as follows: "A waveguide preselector filter shall be installed between the duplexer and signal mixer of the receiver." Delete second sentence and substitute the following: "Provisions shall be incorporated to allow the preselector filter to be installed prior to as well as following the parametric amplifier. The preselector will normally be installed following the parametric amplifier; however, for purposes of demonstrating compliance with test requirement CS-04 of MIL-STD-461 and MIL-STD-462, the preselector may be installed ahead of the parametric amplifier." Change fifth sentence beginning "The insertion loss..." to read as follows: "The insertion loss at the operating frequency shall not exceed 1.0 dB."

Page 40, paragraph 3.11.5.3: Change first sentence to read as follows: "The output of the normal receiver shall be non-limited video, with the signal-to-noise ratio adjustable up to at least 8:1 with one-half volt of noise."

Page 41, paragraph 3.11.6.1: Add the following at the end of the paragraph:

"Each MTI IF amplifier shall have two isolated, closely matched outputs to be used in quadrature MTI processing (3.14.2). Provisions shall be included to balance exactly the two outputs to insure optimum quadrature operation."

Page 41, paragraph 3.11.6.2: Delete text and substitute the following:

"The characteristics of the phase detectors shall be optimum for use with the digital and quadrature MTI systems (3.14.2 and subparagraphs). The output of the phase detectors shall possess a balanced characteristic with essentially equal positive and negative amplitudes. Coherent bi-polar video shall not unbalance with MTI IF gain control and limit level adjustments. Each channel shall include two phase detectors operated in quadrature so as to produce an in-phase (I) and a quadrature (Q) bi-polar video signal. Provision shall be made to shift the COHO input signal phase of the Q phase detector with respect to the I phase detector so as to result in bi-polar video signals at exact quadrature (90^{o}) phase."

Page 41, paragraph 3.11.6.3: First line, change to read as follows: "The output of each phase detector shall be fed." Third line delete the following: "but not less than 1.0 divided by the pulse width in microseconds."

Page 42, paragraph 3.11.6.6: Between sixth and seventh lines, insert the following:

"Receiver image rejection	Not less than 50 dB
Spurious response rejection	Not less than 60 dB
Receiver local oscillator (STALO) radiation (as seen at receiver input terminals)	Not more than -40 dBm"

Page 43, paragraph 3.11.7.1.2: Next to last line, change to read as follows: "noise are equal, while at the same time..."

Page 44, paragraph 3.11.7.1.4: Change fourth line to read as follows: "weather video shall be realigned (destaggered) digitally when..." In fifth line, change "alingment" to "alignment". Change last sentence to read as follows: "At least seven bits shall be used to represent the weather video."

Page 45, paragraph 3.11.7.2.1: Delete the first sentence and substitute the following: "The dynamic range of the DLC shall be not less than 60 dB." Delete last sentence and substitute the following: "With the IF gain setting so that the A to D converter quantizes at any desired level from 15 dB to 30 dB below the RMS noise level, the DLC logarithmic characteristic shall extend a like amount into the noise."

Page 46, paragraph 3.11.7.2.5: Last line, change "cideo" to "video".

Page 48, paragraph 3.11.8.3.3: Add the following at the end of the paragraph: "The STALO shall be isolated and shielded as necessary to meet the radiation requirements of paragraph 3.11.6.6."

Page 48, paragraph 3.11.8.4.1: Add the following after the first sentence: "Outputs from the COHO shall be utilized to generate the transmitter frequency (3.11.8.3.3), to generate basic system timing (3.14.1), and to generate the MTI canceller clock signal (3.14.2.2)."

Page 49, paragraph 3.12: Third line, change "antenna pattern selector." to "receiver cabinet." Last sentence, delete period at end of sentence and add the following: "and with the gas supply disconnected."

Page 49, paragraph 3.12.1: Add the following at the end of the paragraph:

"The insertion loss as measured in the forward direction between any two ports shall not exceed 0.6 dB."

"Receiver image rejection	Not less than 50 dB
Spurious response rejection	Not less than 60 dB
Receiver local oscillator (STALO) radiation (as seen at receiver input terminals)	Not more than -40 dBm"

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Page 49, paragraph 3.12.1: Add the following at the end of the paragraph:

"The insertion loss as measured in the forward direction between any two ports shall not exceed 0.6 dB."

Page 55, paragraph 3.14.2.2: Second line, change "a double canceller" to "double cancellers". Third line, change "the canceller" to "each canceller". Lines four and five, change "the phase detector" to "each phase detector". In fifth line, change "eight" to "nine". Add the following at the end of the paragraph: "the canceller clock shall be derived from the COHO (3.11.8.4, 3.11.8.4.1)."

Page 57, paragraph 3.14.2.11: In second line, change the comma to a period after MTI, and delete the remainder of the sentence. Add the following new sentence: "A swept-frequency audio sine wave shall be provided for checking the velocity response."

Page 58, paragraph 3.14.4.2: In seventh line, delete period after sentence ending in "isolated windows", and insert "which shall have a programmable start and stop range, a programmable start and stop azimuth and shall be independent of the adjoining windows in both range and azimuth."

Page 59, paragraph 3.14.4.5: In fifth line, delete period after sentence ending in "isolated windows", and add to sentence "which shall have a programmable start and stop range, a programmable start and stop azimuth and shall be independent of the adjoining windows in both range and azimuth."

Page 59, paragraph 3.14.4.7: Add the following at the end of the paragraph:

"Azimuth start shall be adjustable from 0^{o} to 360^{o}; azimuth extent shall be adjustable from 16 ACPs up to 1024 ACPs in increments not to exceed 16 ACPs."

Page 59, add new paragraph following paragraph 3.14.4.8:

"<u>3.14.5 Video realignment</u>.- All videos shall be realigned digitally to within 0.2 microseconds as seen at the output of the control and interface assembly. An isolated output of each realigned video signal in digital form (taken prior to the D/A converters) shall be provided for use by external equipment. These outputs shall be available at appropriate connectors or terminal boards."

Page 60, paragraph 3.15: Change the first two sentences in this paragraph to read as follows:

"The T/R subsystem control and interface circuitry includes, but is not limited to system control circuitry and associated DC power supplies, channel selection circuitry, video and trigger line drivers, azimuth data line drivers and video isolation amplifiers."

Page 55, paragraph 3.14.2.2: Second line, change "a double canceller" to "double cancellers". Third line, change "the canceller" to "each canceller". Lines four and five, change "the phase detector" to "each phase detector". In fifth line, change "eight" to "nine". Add the following at the end of the paragraph: "the canceller clock shall be derived from the COHO (3.11.8.4, 3.11.8.4.1)."

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"The T/R subsystem control and interface circuitry includes, but is not limited to system control circuitry and associated DC power supplies, channel selection circuitry, video and trigger line drivers, azimuth data line drivers and video isolation amplifiers."

Page 68, paragraph 3.15.2.3.2: Line 12, change to read as follows: "to the characteristics (except amplitude) listed in 3.15.2.2.1 for any length of". Change the eighth sentence, starting in the tenth line, to read as follows: "In the case of single-channel operation, the signals from the active channel shall be selected as output signals; in the case of dual diversity operation, the output signals shall come from the master-channel."

Change the ninth sentence, starting in the fourteenth line, to read as follows: "Isolated output jacks as required to fully monitor system operation by use of the maintenance PPI shall be provided (3.16.2.5)."

Change the last sentence to read as follows: "Isolated outputs of the antenna azimuth position data shall be provided for use by the maintenance PPI (3.16.2.5)."

Page 69, paragraph 3.15.2.3.3: In line six, change "2V" to "4V".

Page 69, paragraph 3.15.2.3.4: Change the first sentence to read as follows: "Two each azimuth data pulse amplifiers shall be provided." Change the sixth sentence starting in line 12 to read as follows: "Provisions shall be made for switching either amplifier to the various points required at the local site." Add the following to the end of the paragraph: "Signals intended for use at the local site shall be fully isolated from those intended for remoting."

Page 70, paragraph 3.15.2.3.6: In last line, change "3.15.2.2.3" to "3.15.2.3.3".

Page 70, paragraph 3.15.2.4: Change seventh line to read as follows: "link remoting of normal, MTI and beacon videos, radar trigger, and APG information. The". In the fourth sentence, line eight, change "Control interface assembly" to "control and interface circuits". Change the ninth line to read as follows: "MTI video, APG information and aligned radar pretrigger (60 or 100 microseconds) for routing to a microwave link via". After the period in the twelfth line, add the following new sentence: "The ACP and ARP level shall not be less than the levels specified in 3.15.2.2.1 and need not be variable." At the end of the paragraph, add: "At the remote site, provisions shall be made to feed the ACP and ARP information directly from the microwave link into the azimuth data distribution amplifier assembly, bypassing the azimuth data pulse shaper amplifiers."

Page 72, paragraph 3.16.2: On line nine, change "plus or minus 0.2°" to read "plus or minus 0.5°".

Page 73, paragraph 3.16.2.3: Change third line to read: "3.17.1.8.1, 3.17.1.8.2 and 3.17.1.8.6 is not required; however, the power supplies".

Page 73, paragraph 3.16.2.5: Change the first sentence to read as follows: "Appropriate connections shall be provided for all inputs (including power) for the maintenance PPI on the front of each processor cabinet". Change the last sentence to read as follows: "Provisions shall be made to conveniently observe all system videos prior to selecting them for remoting."

Insert the following new paragraphs after paragraph 3.17.1.10:

"3.17.1.11 Electrical Load Characteristics.

3.17.1.11.1 Electrical Load Balance.- When equipment requiring three-phase power is comprised of several single-phase subassemblies the single-phase loads shall be balanced among the three phases as closely as possible, so that the total load on any one phase does not deviate from the average of the three phases by more than 10 percent.

3.17.1.11.2 Power Factor.- The equipment shall be designed so that it presents a power factor not less than 80 percent lagging when operating under normal test conditions (FAA-G-2100/2, paragraph 1-3.2.22).

3.17.1.11.3 Start-up Surges.- The peak inrush current during a start-up shall not exceed five times the normal peak operating current. The duration of the inrush current shall not exceed eight seconds (return to 110% of nominally).

3.17.1.11.4 Effect of Equipment on Power Source.- The total rms current generated at service conditions by the equipment and fed back into an AC supply system with linear impedance characteristics shall not exceed five percent of rms full load current."

Page 79, paragraph 3.18.1: First line, change to read as follows: "Equipment cabinets, except as noted in 3.10.1 and 3.15.2.3.8,". Change sentence beginning on eleventh line to read as follows: "The door half of the hinge shall be secured by means of screws or nuts and bolts, with sufficient play to permit proper door alignment; the cabinet half of the hinge may be bolted or welded on." In line 16, change the period to a semicolon and add the following: "however, termination in a different manner will be considered for the control and interface cabinet (3.15) and the remote site equipment cabinet."

Insert the following new paragraph after paragraph 3.18.1.5:

Page 73, paragraph 3.16.2.3: Change third line to read: "3.17.1.8.1, 3.17.1.8.2 and 3.17.1.8.6 is not required; however, the power supplies".

Page 73, paragraph 3.16.2.5: Change the first sentence to read as follows: "Appropriate connections shall be provided for all inputs (including power) for the maintenance PPI on the front of each processor cabinet". Change the last sentence to read as follows: "Provisions shall be made to conveniently observe all system videos prior to selecting them for remoting."

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Insert the following new paragraph after paragraph 3.18.1.5:

"solid part mounting structure, with adequate protection for printed wiring and small parts when inserting, removing or during handling of modules after removal from the equipment.

Module Removal and Insertion Damage - All equipment shall be designed to enable the removal and insertion of modules and printed circuit card and without causing or inducing damage to any equipment external to the module or printed circuit card.

Induced Transients - A means shall be provided to enable the removal or insertion of any off-line module or printed circuit card without generating any logic or electronic disturbance that may affect the on-line system operation.

3.18.3.2 Mounting.- Plug-in modules and PC cards shall be mounted side-by-side, bookcase style, in an assembly, and shall be equipped with chassis guide strips or rails (or both) and mating connectors, as are necessary to ensure positive alignment of the module connector with its mating receptacle. Quick acting fasteners shall securely lock front panel type of plug-in modules and cards in their operating position when the average withdrawal force is less than 10 pounds.

3.18.3.3 Connectors.- The connector receptacles shall contain a polarizing key and the key location shall be different for each different type of module and card. All assemblies of the same type shall have the same polarizing key location to ensure insertion of the proper type. The keying method shall not reduce the number of connector pins. Mating cojnectors shall be designed for repeated use with the modules and cards to ensure long-term reliable performance, and with suitable mountings to permit insertion without jamming or otherwise damaging the connector elements.

3.18.3.4 Module/card extenders.- A module/card 'extender' shall be supplied for each type of module/card. An extender consists of a printed circuit board (not keyed in order to permit insertion into any connector) provided with printed circuitry and coaxial leads to extend all plug input points across the board to a receptacle on the opposite end, into which receptacle a removed assembly can be plugged. The extender thus provides an accessible active operating position for any assembly normally inaccessible for maintenance and test while within the bin. Provisions shall be included to prevent a module or card from being improperly oriented (for example, a PC card reversed) when the extender is in use. No derogation of system or module performance shall result from proper use of the extenders.

3.18.3.5 Solderless wrapped electrical connections.- Solderless wrapped electrical connections shall be used only for backplane wiring using appropriately designed wraposts (terminals).

Solderless wrapped electrical connections shall be in accordance with MIL-STD-1130. Copper conductors shall be annealed, oxygen-free high conductivity solid copper wire as defined in ASTM-B224. For AWG-28 and smaller wire, the following modifications to MIL-STD-1130 apply:

"solid part mounting structure, with adequate protection for printed wiring and small parts when inserting, removing or during handling of modules after removal from the equipment.

Module Removal and Insertion Damage - All equipment shall be designed to enable the removal and insertion of modules and printed circuit card and without causing or inducing damage to any equipment external to the module or printed circuit card.

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3.18.3.7 Ferrous materials.- When ferrous materials are used with prior approval of the Government, they shall be in accordance with MIL-STD-454, Requirement 15.

3.18.3.8 Wire identification.- Color coding is not required for wires used in backplane wiring. This modifies paragraph 1-3.10.6 of FAA-G-2100/1.

3.18.3.9 Printed circuit cards.- Single layer printed circuit cards shall be in accordance with the requirements of Specification FAA-G-2100/4. Multilayer printed wiring boards shall be in accordance with the requirements of Specification MIL-P-55640 in addition to FAA-G-2100/4. Screwdriver adjustments required for alignment shall be held to a minimum; however, when required, such adjustments shall be made on the circuit card. All cards shall use a common position on the connectors for the power supply and ground leads.

3.18.3.10 Air filters.- Where disposable air filters are used, they shall be in accordance with Federal Specification F-F-310. This modifies paragraph 1-3.9.4 of FAA-G-2100/1. The air filters shall be removable from the outside (exterior) of the equipment cabinets without the necessity of opening access doors or moving any other equipment cabinets.

3.18.3.11 Transformers.- Delete paragraphs 1-3.16.14 and 1-3.16.14.1 of FAA-G-2100/1 and substitute the following:

Transformers, inductors and coils.- Transformers, inductors and coils shall be in accordance with MIL-STD-454, Requirement 14. In lieu of tables 14-I and 1r-II of Requirement 14, the table below applies. Transformers and inductors used for audio, power and high power pulse shall have solder-type or screw terminals (life test and corona test not required unless specifically required in the detail equipment specification). Single phase AC line operated transformers shall not have more than three secondary windings and one center-tap.

SPECIFICATION	GRADE	TEMPERATURE CLASS
MIL-T-27[1]	4 or 5	R
MIL-T-39013	4 or 5	R
MIL-T-21038[1]	4 or 5	R
MIL-T-39026	6 or 7	R
MIL-C-15305	1	B
MIL-C-39010	-	B

[1]Life expectancy X

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MIL-C-39010	-	B

[1]Life expectancy X

3. Synthetic alkyd urea enamel made by Andrew Brown Co. (B440) or equivalent, color brown, color number 30372 per Federal Standard 595, thickness 0.0009 to 0.0013 inches (applicable to smooth surface only, - textured surfaces vary in thickness).

4. QUALITY ASSURANCE PROVISIONS

4.1 General.- The contractor shall establish and maintain a quality control program in accordance with FAA-STD-013. Quality assurance provisions specified in Section 1-4 of FAA-G-2100/1 shall apply. The contractor shall submit test plans and test data sheets for approval by the Government. These tests shall consist of the following:

	Test	Reference Paragraph
(a)	Quality Control (Inspection)	4.1
(b)	Preliminary tests	FAA-G-2100/1
(c)	Design Qualification tests	4.7
(d)	Type tests	4.3 and 4.8
(e)	Production tests	4.4
(f)	System Reliability Demo	4.5
(g)	Corrective Maintenance Demonstration Task	4.6

Tests specified in (a) and (e) above, shall be conducted on each equipment procured under this specification. Tests specified in (b), (c), (f), and (g) above, shall be conducted on the first system. Test (d) shall be performed as required in FAA-G-2100/1 and the number of applicable systems will be dependent on quantity specified in the contract schedule. Modifications to equipment generated as a result of any tests shall be incorporated into each system delivered at no additional cost to the Government.

4.1.1 Procedures.- Submission and approval of test procedures shall be as specified in FAA-STD-013a.

4.2 Unused.

4.3 Type tests.- Type tests under the service conditions (3.2) shall be performed in accordance with 1-4.3.3 and subparagraphs and 1-4.12 and 1-4.12.1 of FAA-G-2100/1. One complete channel and the common equipment of each type test system are required to be tested under service conditions. The second channel shall be connected to the first channel and operated under normal test conditions, or alternatively, signals and other inputs from the second channel may be simulated. Antenna type testing may be performed separately; however, the type test system shall be connected to an installed and operating antenna so as to provide a true operating environment. The channel being tested under service conditions shall be selected as the master channel. Complete systems or additional items of equipment scheduled for shipment subsequent to the system being type tested shall not be accepted by the Government nor shipped from the contractor's plant until the type tests have been completed on one system and the type test results determined to be satisfactory by the Government.

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RF plumbing, pressurization integrity	3.12
Diversity operation	3.13
Trigger requirements	3.14.1.2
MTI system performance	3.14.2
Built-in test equipment (BITE)	3.14.2.11
Video test pulse generator	3.14.2.12
Video enhancer	3.14.3
RAG performance	3.14.4
Point of control	3.15.1
Alarm controls	3.15.1.11
Radar output signals	3.15.2.2
Cable remoting system	3.15.2.3
Maintenance PPI performance	3.16.2
Power supply metering	3.17.1.8.6

Subsystem/Unit Production Tests

Radiated frequency	3.3.3
RF drive	3.10.9
Parametric amplifier	3.11.1.4
Receiver IF frequency	3.11.3
IF band-width	3.11.5.2
IF amplifier	3.11.6.1
Phase detector	3.11.6.2
Antenna	3.3.3
Factory run-in test (antenna)	3.8.4.6
Contour deflection	3.8.7.1
Operating parameters (Rotary joint)	3.8.8.1
Isolation (Rotary joint)	3.8.8.2
Azimuth pulse generators	3.8.9.3
Voltage standing wave ratio (antenna)	3.9.2
Antenna pattern (electrical) tests	3.9.13
X-radiation sheilding	3.10.6

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Voltage standing wave ratio (antenna)	3.9.2
Antenna pattern (electrical) tests	3.9.13
X-radiation sheilding	3.10.6

4.7.4 System coverage verification.- Unit and system performance characteristics shall be measured as necessary to verify the specified system coverage (3.3.2). Utilizing the actual measured values, range calculations shall be performed, with the results verifying the requirements of 3.3.2.

4.7.5 Vibration and noise.- Antenna assembly noise measurements shall be performed to determine compliance with specified requirements (3.8.2.6).

4.7.6 Antenna median gain.- Antenna median gain shall be measured as a design qualification test. Data shall be recorded as necessary to determine the antenna median gain (paragraph 3.9.1) over 360 in the principal azimuth plane. The median gain specified in paragraph 3.9.1 is not a requirement unless specified in the contract; however, range instrumentation and data recorded shall be adequate to determine whether or not the median gain is at the -10db level.

4.8 Type test requirements.- The contractor shall submit type test procedures and test data sheets for approval by the Government. As appropriate, system performance tests shall be made in all modes of operation, i.e., single channel/dual diversity; in phase/quadrature MTI; unstaggered/staggered PRF, etc. All the following paragraph references hereunder shall include subparagraphs thereto. Type tests shall consist of the following:

	Test	Reference Paragraph
S, V	Transmitter peak power	3.3.3
S, V	Pulse width	3.3.3
S, V	Noise figure	3.3.3
S	Minimum Discernible Signal (MDS)	3.3.3
S, V	MTI system	3.3.3
S, V	Factory run-in test	3.8.4.6
	Operating characteristics (Rotary joint)	3.8.8.1 3.8.8.2
	Azimuth pulse generator	3.8.9.3 3.8.9.4
	Antenna (electrical) pattern tests	3.9.13
S	RF pulse spectrum	3.10.2.4
S, V	Transmitter output tube	3.10.3
S	Frequency tolerance	3.10.9.2
S	Receiver gain control/STC/ Antenna beam selector	3.11.1.2

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	Antenna (electrical) pattern tests	3.9.13
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S, V	Transmitter output tube	3.10.3
S	Frequency tolerance	3.10.9.2
S	Receiver gain control/STC/ Antenna beam selector	3.11.1.2

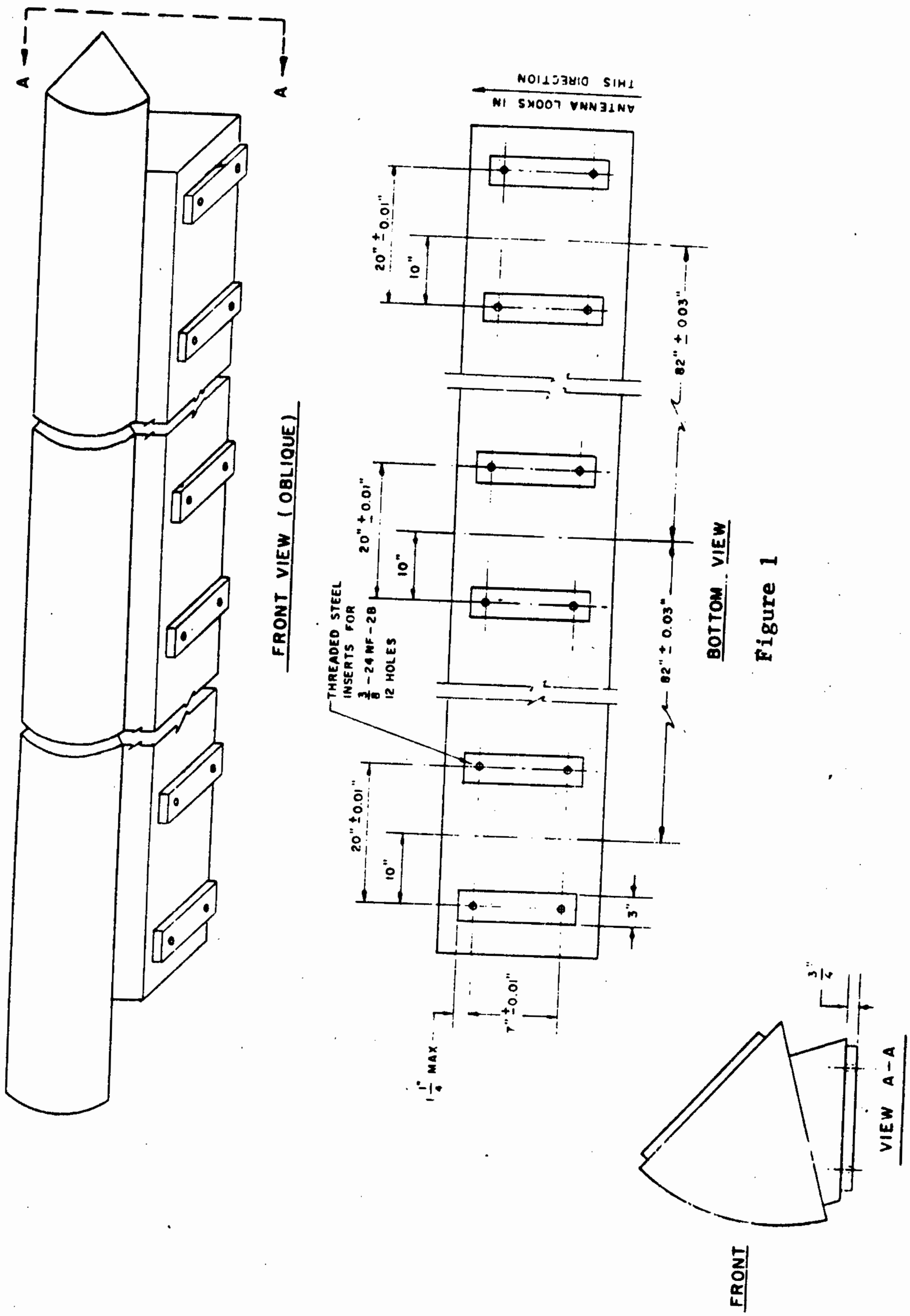
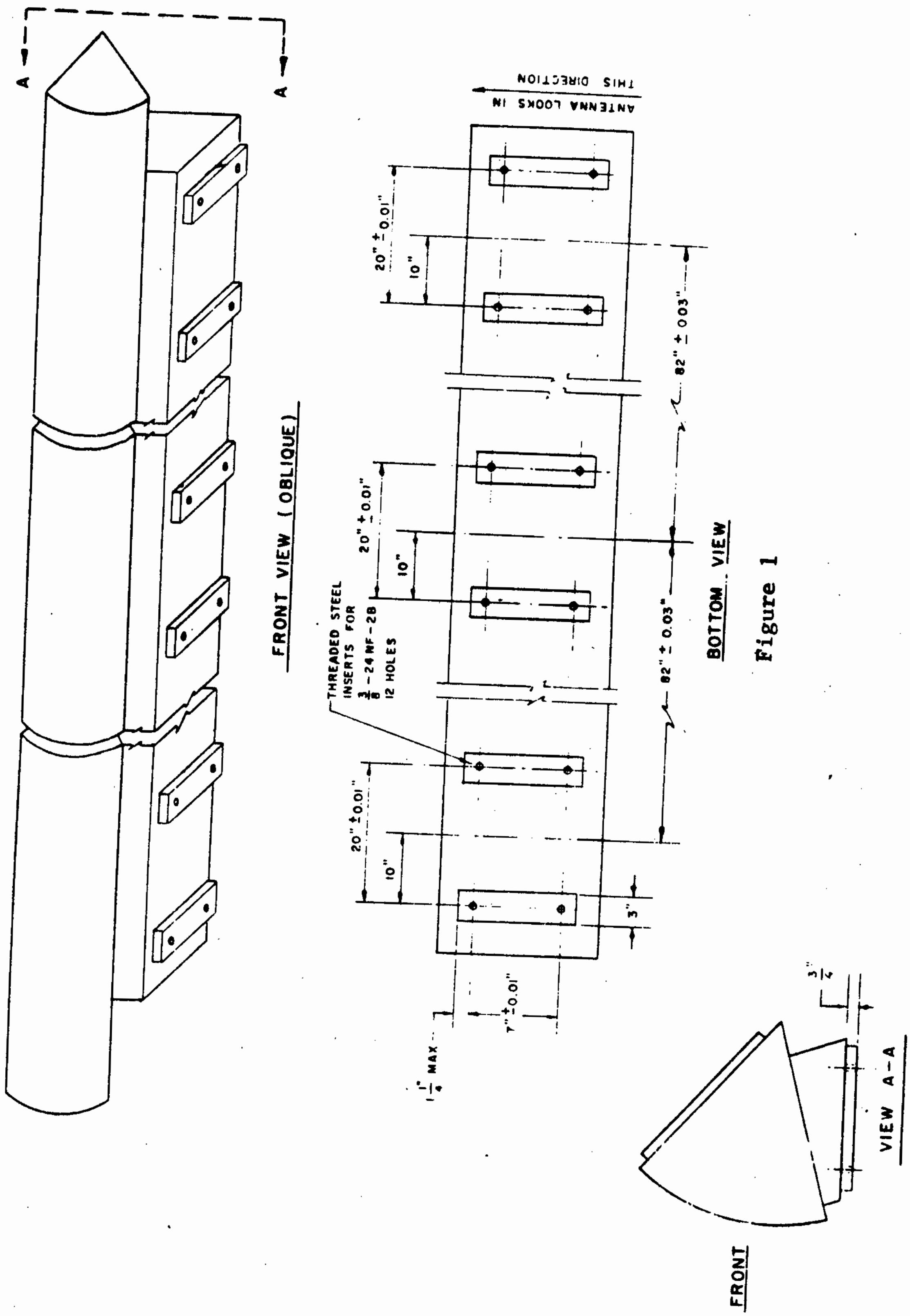

A
A
FRONT VIEW (OBLIQUE)
ANTENNA LOOKS IN THIS DIRECTION
20" ± 0.01"
10"
82" ± 0.03"
20" ± 0.01"
10"
82" ± 0.03"
THREADED STEEL INSERTS FOR 3/8-24NF-2B 12 HOLES
20" ± 0.01"
10"
3"
7" ± 0.01"
1 1/4" MAX
BOTTOM VIEW
3/4"
VIEW A-A
FRONT

Figure 1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